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FUNGI AND WATER

By C. T. INGOLD

A fungus may be said to meet its first water problem as its spores, during their dispersal through the air, are whirled from eddy to eddy. Quite apart from the slender chance that any one spore has of landing in a place suitable for growth, there are other hazards of aerial transport. Thus the spore may be adversely affected by the temperature of the air or by the light, especially ultra-violet light, falling upon it. What interests us at the moment is that during its flight the spore is likely to be desiccated to a greater or lesser extent and this might well lead to loss of viability. On the whole, however, the evidence suggests that this is not a serious matter for many species. Most fungus spores can be air-dried without ill effects, probably because they are normally without vacuoles, for in general plant cells filled with protoplasm are much less sensitive to drying than are vacuolated cells. Air-dried sporangiospores of *Rhizopus stolonifer* have been kept for over thirty years and have subsequently germinated (McCrea, 1931). Air-drying of spores may, indeed, increase their resistance to other harmful influences.

The next water hazard for the fungus is associated with germination. At this stage water must normally be available if the spore is to swell and put forth its germ tube (Gottlieb, 1950). The spores of some species can germinate only in the presence of liquid water. Others can germinate on an unwetted surface if the relative humidity of the surrounding air is over 90 %. However, certain powdery mildews, e.g. *Erysiphe polygoni*, are unique in being able to germinate freely in equilibrium with air having a relative humidity as low as 75 % (Brodie & Neufeld, 1942), but other species of the same genus need a relative humidity exceeding 90 %. The problem of germination in relation to humidity is complicated by the fact that, as in so many physiological processes, a single factor cannot be considered in isolation. Thus it has been clearly shown (Tomkins, 1929) that the humidity requirements for germination are not the same at different temperatures and at different levels of nutrient supply.

Probably for successful germination most fungal parasites of herbaceous plants need free water. This means that the infection drops provided by dew or rain are of special significance. In this connexion the duration of these drops is important, for, if the fungus is to succeed, the drops must persist long enough not only for germ tubes to be formed, but also for these to penetrate and reach the wet tissue below the cuticle or the damp air of the intercellular spaces of the host. The successful parasite may have to time the liberation of its spores rather nicely if it is to catch the dew-drops.

Once the spore has germinated, its further growth still depends on water supply. For fungi parasitic on the sappy tissues of herbaceous plants there is ample. All that is necessary is that the fungus can exert a sufficient suction to utilize the water. There is experimental evidence (Thatcher,

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Vol. 37, *Part* 1: *issued* 19 *March* 1954.

1939) that in general the osmotic pressure of parasitic fungi exceeds that of their hosts.

Growth of saprophytic fungi in relation to water may be illustrated, perhaps, by a consideration of wood-destroying species. In this connexion much work has been undertaken because there is the practical question of how dry wood must be if it is to be free from fungal decay. The general answer is that provided the water content is less than about 22 % of the dry weight, the wood remains free from fungal attack (Cartwright & Findlay, 1946), although, under experimental conditions where the air is stagnant, *Merulius lacrymans* can grow on wood with a water content below 20 %. Amongst the wood-rotting fungi tested *Stereum frustulosum* is considered to be most xerophytic (Bavendamm & Reichelt, 1938). This species apparently owes its ability to obtain water from wood of a very low water content to the fact that it can develop a suction pressure as high as 200 atm.

We may digress here to notice that there has been considerable work on the suctional powers of fungi. An extreme example is cited by Raciborski (1905) who grew a species of *Torula* in an aqueous solution saturated with lithium chloride. The osmotic pressure of this was about 1000 atm., so presumably the suction pressure of the fungus exceeded this figure. It is to be noted, however, that if the ions or molecules of the external solution penetrate rapidly into the fungal hyphae, the maximum osmotic pressure of the external solution permitting growth may give an exaggerated value of the suction pressure of the fungus. Thus *Rhizopus stolonifer* cannot grow in a solution of osmotic pressure over 16 atm. when the solute chiefly responsible for producing the osmotic effect is calcium nitrate, but can grow in a glucose solution with an osmotic pressure exceeding 60 atm. (Hawkins, 1916). This discrepancy may be due to the rapid entry of glucose molecules. In higher plants sugars are generally considered as substances that penetrate very slowly into living cells, but probably the permeability relations of fungal cells are quite different. Thus we should be very cautious in estimating the suctional powers of fungi on the basis of their ability to grow on concentrated solutions.

To return to fungi growing on wood, we have seen that provided the water content is above 22 % growth and rotting occur, but the optimum water supply is in the region of 35–50 %. However, at still higher values growth may be reduced, probably due to limitation of oxygen supply or to accumulation of carbon dioxide when gaseous diffusion is restricted by liquid water in the vessels and fibres.

A special point which should be made is that once a fungus is established in wood, the potential water supply is not restricted to the actual water present, for the water content may rise considerably due to the production of water from the organic material of the wood, especially the cellulose, by the metabolic activity of the fungus. This may explain what appears to be a general rule, namely, that the minimum moisture content of wood which allows spore germination is higher than that permitting mycelial growth.

A wood-destroying fungus may, as it were, take steps to conserve its water supply. The 'black-lines' or 'blocking layers' formed by so many fungi that attack tree trunks (e.g. *Armillaria mellea* and *Ustulina vulgaris*) normally delimit a definite volume of wood permeated by the fungus. Buller (unpublished) cut cylinders from tree trunks decayed by *Polyporus* spp., *Fomes* spp. and *Armillaria mellea* and allowed these slowly to dry. As a result of exposure a 'blocking layer' was formed just below and parallel with the surface. He considered this as a type of wound-healing. No doubt this blocking layer retards water loss from the volume of wood occupied by the fungus.

The special case of wood-rotting fungi has been considered largely because it has been rather fully studied, but the general principles of the water relations of saprophytic growth and survival are essentially the same in other organic substrata.

We may now turn our attention to the consideration of water in relation to the development of aerial structures. In these, fungal tissue is exposed directly to the air. Evaporation becomes of critical importance and compensation for water loss is possible only by translocation from the feeding mycelium in the substratum. As a concrete example we may consider the production of aerial sporangiophores in members of the Mucorales. Thus when *Phycomyces blakesleeanus* and *Mucor hiemalis* are grown on agar in small open vessels* placed in a desiccator over water, the *Mucor* forms a dense aerial growth up to 2 cm. high consisting of sporangiophores and other aerial mycelium, while the *Phycomyces* produces a crop of long aerial sporangiophores 8–10 cm. high unaccompanied by other hyphae. When, however, these two species are grown in a similar manner but in a desiccator over anhydrous calcium chloride, the only aerial growth in *Mucor* is a low felt about 1 mm. high limited to the damp air in immediate contact with the agar. However, the sporangiophores of *Phycomyces* grow up as freely and as high as in the damp air. This xerophytic behaviour of *Phycomyces* is probably due to two special features: the nature of the sporangiophore wall which seems greatly to retard evaporation, and the well-developed water conduction through the broad coenocytic hyphae that supply the sporangiophores.

Little is known with any degree of exactness concerning the effect of the humidity of the air on the production of the complex sporophores of higher fungi. Hopp (1938) has, however, studied the formation of sporophores by *Ganoderma applanatum* growing in culture on poplar blocks under conditions of controlled humidity. He reached the conclusion that normal sporophores are formed only under conditions of good aeration and when the moisture supply to the mycelium in the wood is sufficient. However, if the relative humidity of the ambient air is too high, normal fruit-bodies are not produced. In his experiments typical sporophores were formed in culture at a relative humidity of 73 % but not at 53 % or at 100 %, although sporophores of a kind were produced at all these levels of dampness. Such results should, however, be interpreted with some caution because of the technical difficulties of maintaining the air around a developing fruit-body at a constant known humidity.

Once a fruit-body is produced, the successful liberation of spores may be greatly influenced by water supply. In both Discomycetes and Pyrenomycetes spore discharge involves the bursting of turgid cells. In the Hymenomycetes, whatever may be the exact mechanism of the basidium, it seems certain that it can function only when turgid. Hence, if discharge is to go on, a constant supply of water to maintain the turgidity of the elements of the hymenium is essential.

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* 1 × 1 × 1 in. specimen tubes are suitable.

The fleshy fruit-body of an agaric or a *Boletus* is itself a considerable water reservoir, and spore discharge can continue for some hours when a sporophore is exposed to dry air. However, in most such fungi there is little or no structural check on evaporation, nor does there seem to be any significant translocation of water from below. Thus, in dry air, the water content of the fruit-body soon falls below the critical level and spore discharge ceases. Further, most fleshy fungi have no power of subsequent recovery after a period of drying.

In a few fleshy fungi, however, water does seem to flow freely to the hymenial surface. A case in point is *Mitrula phalloides*. In its vegetative life this is an aquatic fungus with the mycelium growing in submerged twigs and leaves, but the apothecium is a stalked aerial structure. If a specimen is brought into the laboratory and arranged in a weight potometer with the substratum submerged in water, but with the apothecium projecting, and if precautions are taken so that water loss can occur only from the apothecium, then transpiration can be followed by measuring loss of weight. In such a set-up placed in a desiccator containing anhydrous calcium chloride and observed over a period of four days, spore discharge continued unchecked and water loss was continuous and steady. At the end of the period 8·9 g. had been transpired and the stalked apothecium, which appeared turgid and healthy, was found to weigh 0·86 g. Thus during the experiment it had transpired ten times its own weight of water. In all probability in this fungus translocation is by capillarity between the hyphal threads in the stalk. In other words, the stalk acts as a wick. Probably water transport in many marsh agarics, such as the species of *Galera* that habitually grow in *Sphagnum* cushions, is of this nature, but the matter requires experimental study.

The sporophores of most fleshy fungi have few xerophytic characteristics apart from their water reserve which is so largely unprotected. However, the leathery, corky and gelatinous sporophores of lignicolous fungi are xerophytes of the drought-enduring type. A well-known example, discussed long ago by Buller (1909), is *Schizophyllum commune*, very frequent on fallen beech trunks in autumn and winter. Under damp conditions the sporophore absorbs water, the cells become fully turgid and spores are discharged. With the onset of dry conditions the fruit-body loses water, spore discharge ceases and in this peculiar species the gills are split and roll backwards so that the dry hymenium is no longer exposed. Whether this has any biological advantage is far from clear. On the return of wet weather, water is rapidly absorbed, the gills resume their normal form and spore discharge soon recommences. In an experiment planned and started by Buller many years ago and now continued by Bisby (1945) it has been shown that the dry sporophore can retain its viability for a quarter of a century and then liberate its spores freely a few hours after wetting. In nature, however, the sporophore lasts only for a single season, and this seems to be generally true for this large class of drought-enduring lignicolous xerophytes.

It should be emphasized that this ecological group includes not only Basidiomycetes, but also a wide range of Ascomycetes. Most of the Pyrenomycetes of wood and bark are drought-enduring xerophytes.

Forming somewhat of a contrast are certain species, apparently very few in number, which are able to sustain their spore discharge throughout the dryest days of summer, and are not directly and immediately dependent on rain.

In *Ganoderma applanatum* spore discharge continues from May until October (White, 1919), and during this period is largely unaffected by rainfall and humidity. Thus at the beginning of September 1947, after a period of intense drought that had already lasted over a month, I observed ferruginous clouds of spores still escaping from a sporophore in Knole Park. Buchwald (1938), in *Fomes fomentarius*, has found that if a section of a tree trunk bearing a fruit-body is brought into the laboratory and freely exposed, spore discharge may continue for weeks or months. I have found, however, with this species and with *Ganoderma applanatum* that isolated sporophores brought indoors in the early summer continue to shed spores for only a very few days. It can be shown that in *Ganoderma* water loss from both upper and lower surfaces of the sporophore is relatively rapid. Using a fine specimen of *Ganoderma* in its second year, collected during the spring foray at Flatford Mill in 1948, I measured in the laboratory a water loss of 5–6 mg./cm.^{2}/hr. from the lower surface and 2–3 mg./cm.^{2}/hr. from the upper over a period of 4 days. The early cessation of spore liberation in isolated fruit-bodies is probably due to falling water content and to the fact that the reserve in the sporophore is relatively small. The continuation of spore discharge in sporophores attached to substantial sections of tree trunks may be attributed mainly to the water reserve in the wood. As we have seen this reserve is in part present as water, and in part as potential water which may be generated by the action of the vegetative mycelium as it attacks the wood.

It is of interest to note that, so long as the general water content of the sporophore is maintained, the spore-bearing surfaces within the long narrow hymenial tubes are almost completely protected from evaporation. Within these tubes, even at times of high winds, the air is quite still and humid. Indeed, the long narrow hymenial tubes may be regarded as part of xerophytic equipment of the perennial polypores.

Just as *Ganoderma* and *Fomes* are unusual amongst Hymenomycetes in being able to liberate spores in dry weather, so is *Daldinia concentrica* amongst Pyrenomycetes (Ingold, 1946). In this fungus the relatively large annual stroma is produced by rapid growth in late summer and early autumn from the perennial mycelium in a dead trunk or large limb of ash. The discharge of ascospores begins sometime in late April or early May. If stromata are carefully detached early in April, brought indoors and freely exposed without any extraneous water supply, spore discharge begins about the middle of the month and continues nightly for 30–40 days. During this period the density of the stroma falls from just over 1·0 to about 0·3, its volume remaining virtually unchanged. Clearly the water necessary for discharge is being derived from the reserve in the stroma. I have also followed discharge daily from an attached stroma on an ash tree in my garden. It was kept under observation from March to October of last year. Discharge began on 3 May and continued nightly until 17 September, a period of 138 days. This isolated observation that an attached stoma can maintain its spore output considerably longer than a detached one suggests that as the water reserve in the stoma is exhausted, it is made good by translocation from the reserve in the wood.

A problem in *Daldinia* is how the water, and also probably food, is translocated to the surface crust containing the perithecia. This is part of the more general problem of translocation in septate fungi, but it is of interest to note that there is a distinct tissue differentiation within the stroma, quite apart from the characteristic concentric zoning which is caused by regions of thick-walled hyphal alternating with regions where the hyphae have thinner walls. If radial and tangential sections of the stroma are examined it may be seen to be penetrated by a system of anastomosing veins, and it is tempting to compare these with the network of a leaf.

It will be clear from the foregoing discussion that where a reproductive structure is able to remain constantly turgid and functional in spite of the dryness of the ambient air, translocation of water is of extreme importance, and the failure of most aerial fungal structures to continue to operate in an atmosphere of low humidity is largely correlated with a general lack of efficient water-conducting systems in fungi. It may, therefore, be of interest to discuss some examples in which water conduction clearly obtains.

We have seen that capillary conduction between interwoven hyphae, as in a wick, is suspected in *Mitrula*, but this mechanism can operate only when free external water is fully available in the substratum.

Efficient conduction also occurs in the hyphae of *Phycomyces* and other members of Mucorales and is readily visible. It is referred to as streaming, although it is of quite a different nature from the streaming so well known in the cells of higher plants. It is caused by localized water loss, and streaming occurs towards the point where evaporation is taking place (Arthur, 1897; Schröter, 1906; Andrews, 1912). In the hyphae of *Phycomyces* in which streaming is occurring there is a lining layer of protoplasm which undergoes little or no movement. Inside this is the vacuole, but this is interrupted at certain points along its length by protoplasmic masses each surrounded by its own plasma membrane and hence free to move independently of the lining cytoplasm. When streaming is induced by water loss from the sporangiophores, it is the movement of these protoplasmic masses that is visible, although the intervening sap is moving as well. In the same way the movement of water in a capillary tube is made apparent by included air bubbles.

If a Petri-dish culture of *Phycomyces*, exposed to dry air, is observed under the microscope, rapid streaming in many of the larger hyphae can be seen, and, if any one stream is carefully followed, it will be found to lead into a large sporangiophore. I have made a few observations on the rates of flow into sporangiophores and these vary from 1 to 10 mm.^{3}/hr.

When we turn to the higher fungi where the mycelium is septate, knowledge of the channel of water flow and of the factors causing movement is very inadequate. Streaming occurs somewhat as in *Phycomyces* and protoplasm appears to flow freely from cell to cell through the central pore of each cross-wall, but the direction of flow would seem always to be from the older regions towards the tips of growing hyphae and there is no evidence that it is motivated by transpiration (Buller, 1933). Indeed, the mechanism of flow seems to be connected with vacuole formation in the older cells which pushes the protoplasm forward towards the growing hyphal tips. Extensive water transport almost certainly occurs in the dry-rot fungus *Merulius lacrymans* through the long rhizomorphs that are sometimes formed. Starting at an operational base in some damp cellar, this fungus can spread even over brickwork and attack relatively dry wood at some distance from its base. It would seem that this type of attack is possible because of water conduction. Falck (1912) has studied the anatomy of these rhizomorphs and has figured large thick-walled hyphae with infrequent cross-walls which look much as if they were conducting elements. However, it is always dangerous to deduce function from form, and it would be interesting to have experimental evidence that water can be conducted readily through these channels.

We have seen that in *Fomes* and *Ganoderma* there must be continuous translocation into the sporophore to make good the transpirational loss, but there is no anatomical evidence of specialized conducting elements.

One final point should be made about water transport in fungi. There is no suggestion of separate channels concerned with water and with food conduction which is such a striking feature of higher land plants. The whole problem of conduction in fungi is in need of careful experimental study.

In fungi water is lost mainly by evaporation, but exudation of liquid water may sometimes occur. Thus the appearance of droplets on the surface of the sporangiophore is very familiar in *Pilobolus* and the weeping of *Merulius lacrymans* is responsible for the specific epithet. Indeed, water exudation is often a feature of developing polypores in the field. Both *Polyporus hispidus* and *P. dryadeus* are outstanding in this connexion.

In the green cryptogams of the land flora (i.e. bryophytes and pteridophytes) dry conditions are essential for spore liberation. In most fungi, however, dampness is essential, since the spore-discharge mechanisms involve the activity of turgid living cells. There are, however, many dry-spore moulds (e.g. *Rhizopus stolonifer*, *Penicillium* spp., *Cladosporium herbarum* and *Alternaria tenuis*) in which dryness in no way retards the liberation of the spores. Again, sudden changes in humidity may occasionally be of importance as in the discharge of conidia from the hygroscopic conidiophores of *Peronospora tabacina* (Pinckard, 1942).

It is of interest briefly to consider rain in relation to the fungi, apart from its importance in preserving the dampness of the substratum. First, it seems certain that the hymenomycete hymenium is ruined by free water and hence its protection from rain is of considerable importance. I think it is true to say that the fruit-body of a toadstool looks so like an umbrella that most mycologists have ignored the importance of the shelter afforded to the hymenium by a structure of this kind. That which is too obvious is often overlooked.

Raindrops may be important in bringing about spore liberation. Gregory (1949) has shown that the puffing mechanism of *Lycoperdon* and *Geaster* is operated to perfection by large raindrops, or by drips from the wet leaf-canopy of the forest. Brodie (1951*a*) has, in beautiful detail, developed the thesis that the 'bird's nest' fruit-bodies of *Crucibulum* and particularly *Cyathus* are essentially splash-cups from which the peridiola are discharged to distances of several feet. He has shown that a very similar mechanism has been developed in *Polyporus conchifer* in connexion with the discharge of the oidia (Brodie, 1951*b*). Further, many microfungi with slime spores probably rely on rain-splash for dispersal. Thus in *Colletotrichum lindemuthianum*, the cause of anthracnose of dwarf and runner beans, the spores are splashed from diseased to healthy plants and so infection is spread.

Raindrops may have a further influence in the fungi. Gregory (1951) has suggested that for many small-spored species the problem of making a land-fall is a very real one. The spores tend to stay up in the turbulent air and to slip past solid objects instead of being impacted thereon, but they may be picked up by falling raindrops and so brought safely to the ground.

Before leaving the terrestrial fungi I should like to refer to the general question of xerophytism in fungi. It seems that the xerophytic equipment of a species is compounded of the xerophytism of its several stages: the capacity of the spores to suffer drying without injury especially during dispersal; the ability of the spores to germinate at relative humidities below 100 and on substrata that are not water-saturated; the ability to grow on organic matter of relatively low water content and to survive when conditions become drier still; the readiness with which sporophores are formed even when the air is not saturated; the capacity of the sporophore to produce and continue to liberate spores under relatively dry conditions or, at least, to survive in a quiescent state during periods of drought.

There is probably no fungus that is xerophytic in all its stages. Some species have certain elements of the xerophytic make-up but lack others; many are not xerophytic at all.

Although most fungi are terrestrial, about 1 or 2 % of the species are aquatic. For the permanently submerged water fungus there is no water problem either in connexion with vegetative growth or with spore production, but when it comes to dispersal there are special problems since water is such a very different fluid from air, particularly so far as its density and viscosity are concerned. There are really two major problems: first, the actual dispersal of the reproductive units, and secondly, their arrest on a suitable substratum.

When we consider submerged aquatic fungi we can distinguish two types: the primitive aquatic forms which reproduce by zoospores and in which the whole evolutionary history would seem to have occurred in water, and the aquatic species of Ascomycetes, Hyphomycetes and Sphaeropsidales, the remote ancestors of which were probably terrestrial fungi. There do not appear to be any wholly submerged aquatic Basidiomycetes.

The zoospore is obviously a reproductive unit suited only for life in water, but it is legitimate to consider the biological value of its motility. This may be of importance in connexion with the escape from the sporangia, with dispersal or with coming to rest on an appropriate substratum. In many chytrids the zoospores are in violent activity within the sporangium and then can be seen to swim out singly, but in others, and in many of the larger water moulds, the spore-mass simply oozes out of the zoosporangium, and it is only subsequently that the flagellar movements of the zoospores develop. In actual dispersal it may be doubted if the motility of the zoospores has much significance, since the water movements are usually large in comparison with the feeble efforts of the zoids. However, when it comes to the problem of arrest on a suitable substratum, their movements may be of considerable significance, since by virtue of their taxisms, especially their chemotaxis, they may 'select' a suitable organic substratum (Müller, 1911).

It is what we may call the remigrant aquatic fungi rather than the primitive aquatics that have specially interested me in the past dozen years. I became particularly interested in a regular flora of aquatic Hyphomycetes found on submerged decaying leaves and small undecorticated twigs in streams and other well-aerated waters. Most of the species are very common and many of them seem to have a world-wide distribution. The vegetative mycelium occurs in the decaying tissue, but the conidiophores project into the water. The spores are produced, liberated and normally dispersed below water. The interest is that the form of the spore tends to be peculiar. A few species have more or less conventional spores of a spherical or ovoid form, but in most the conidia are branched structures or they are long and worm-like. Amongst the branched forms the most usual type consists of a spore with four long, narrow arms diverging from a common source. However, the four-armed spore develops so differently in the various species that they have to be distributed amongst quite a number of genera (Ingold, 1942, 1943, 1952). Clearly the tetraradiate spore has developed along a number of separate evolutionary lines. In most species the spore is attached to its conidiophores by the tip of one of its four arms. This is so in *Clavariopsis aquatica*, *Tetrachaetum elegans*, *Articulospora* spp., *Tetracladium marchalianum*, *Heliscus longibrachiatus* and *Alatospora acuminata*. In other species the spore is attached to its conidiophore near the point of divergence of the four arms. This is true in *Lemonniera aquatica*, *Triscelophorus monosporus* and *Actinospora megalospora*. It is very pretty how we can get pairs of genera, each pair consisting of one genus with phialospores and the other with terminal thallospores, but in each pair the mode of development of the four arms of spore is the same. Thus in *Lemonniera* with phialospores and *Actinospora* with terminal thallospores the spore is attached near the point of divergence of the arms which develop simultaneously. In *Alatospora* with phialospores and *Tetrachaetum* with thallospores the spore is attached to its conidiophore by the tip of one of its arms. In these two genera the tetraradiate spore itself consists of a main axis bent in the middle, thus forming two arms, and two laterals which arise simultaneously at the point where the main axis is bent. In *Clavariopsis* with thallospores and *Heliscus* (especially *H. longibrachiatus*) with phialospores the spore is again attached at the tip of one of its arms, but in development the first-formed arm is stouter than the rest, and the other three arise simultaneously as a crown of outgrowths from the blunt apex of the first arm.

Since the tetraradiate spore has so clearly been developed over and over again in these Hyphomycetes it is reasonable to suggest that it may have some biological significance in the aquatic environment. Perhaps such a spore sinks more slowly and so stands a better chance of dispersal, but it seems to me more likely that its importance lies in it being a minute anchor which may easily become entangled in a suitable substratum. In a stream the coming to rest of the spore in a position suitable for germination may be a real problem.

It is of interest to notice that in the marine hyphomycete *Orbimyces spectabilis* (Barghoorn & Linder, 1944) a branched spore with long arms is also formed and, more spectacular still, some species of the brown seaweed *Sphacelaria* produce tetraradiate vegetative propagules with a striking resemblance to the spores of some aquatic Hyphomycetes. Again, in some of the saprophytic marine Pyrenomycetes the ascospores have mucilaginous appendages which could well be interpreted as of value in anchorage.

For the long worm-like spore with a curvature, often sigmoid, lying in more than one plane, a story can be suggested along the same lines as that for the tetraradiate spore. Amongst aquatic Hyphomycetes, *Flagellospora curvula* with phialospores and *Anguillospora longissima* with terminal thallospores have spores of this kind; amongst aquatic Ascomycetes the long narrow sigmoid spores of the fresh-water discomycete *Apostemidium guernisaci* and those of the marine pyrenomycete *Halophiobolus marina* are very similar, and bearing these spores in mind it is suggestive to remember that in *Zostera*, the only British genus in which pollination occurs below water, the pollen grains are long narrow filaments.

Some attention has been directed in recent years to the 'spora' (Gregory, 1952) of the air, but there is a spora of the water too. This is rather difficult to sample, but a natural accumulation of it can be seen in the scum on a fast-flowing stream. In a babbling brook a brown foamy scum often collects behind a barrier of twigs. If this is collected and examined under the microscope, especially in autumn and winter, a wonderful collection of spores can be seen with tetraradiate ones predominating. If such a preparation is compared with the aerial catch by slit samplers (e.g. a cascade impactor) the amazing differences between the spora of the air and of the water of a stream are at once apparent.

I have considered water in relation to fungi, but have by no means given an exhaustive treatment of this large subject. The point I want to emphasize in conclusion is that whether we are considering the life processes of fungi or whether we are trying to interpret fungal structure, we must never lose sight of the importance of water.

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THE ASCOGENOUS HYPHAE IN *DALDINIA*

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(With 2 Text-figures)

The morphology of the ascogenous hyphae of *Daldinia concentrica*, as seen in squash preparations of the contents of the mature living perithecia, is described. The special feature of these straight, unbranched, non-septate hyphae is the elongation of the growing tip between successive stages of crosier formation so that each bears a series of lateral asci.

The study of ascogenous hyphae has largely been based on microtome sections of apothecia and perithecia usually in a rather young condition. However, in squash preparations of mature fresh material short lengths of these hyphae are often to be seen with the asci arising very close to one another.

During an examination of the living perithecial contents of *Daldinia concentrica* (Bolton ex Fr.) Ces. & de Not. considerable lengths of ascogenous hyphae were observed, and this paper is concerned with their morphology.

Perithecial stromata are ripe from early in May to mid-September. If an active specimen is broken vertically, rather than cut with a knife, the perithecia can be seen below the hard black limiting crust and the contents of each appear as a small slimy droplet. This is viscous and can easily be dissected out and transferred to a drop of water on a slide. If this droplet is gently squashed under a cover-glass, the individual ascogenous hyphae are forced apart. Some of these hyphae are shown in Fig. 1. Most of the asci remain attached, but a number may break off. The ascus appears to have a region of weakness near its base, but even if it does become detached, the basal stump is left on the ascogenous hypha.

Each ascogenous hypha is an unbranched non-septate structure up to 450 μ long and almost straight except for a slight step-like kink at the insertion of each ascus. Asci are borne laterally, being developed in succession with the youngest towards the apex and the oldest towards the base. In a specimen shown in Fig. 1, fourteen asci in various stages of development are shown. Some are represented only by their basal regions. The internodal distance between the insertion of asci may be as much as 50 μ. On the whole the internodes tend to be longer in the older parts of the hypha, and sometimes towards the growing apex the asci may be so close together that the internode completely disappears. The asci tend to be produced on one side only of the hypha, but in squash preparations it is difficult to be certain that this is a general rule, particularly in regions of the ascogenous hyphae where the internodes are long.

The apical growing point of the ascogenous hypha, which may be straight or bent into a crozier according to whether the hypha is undergoing

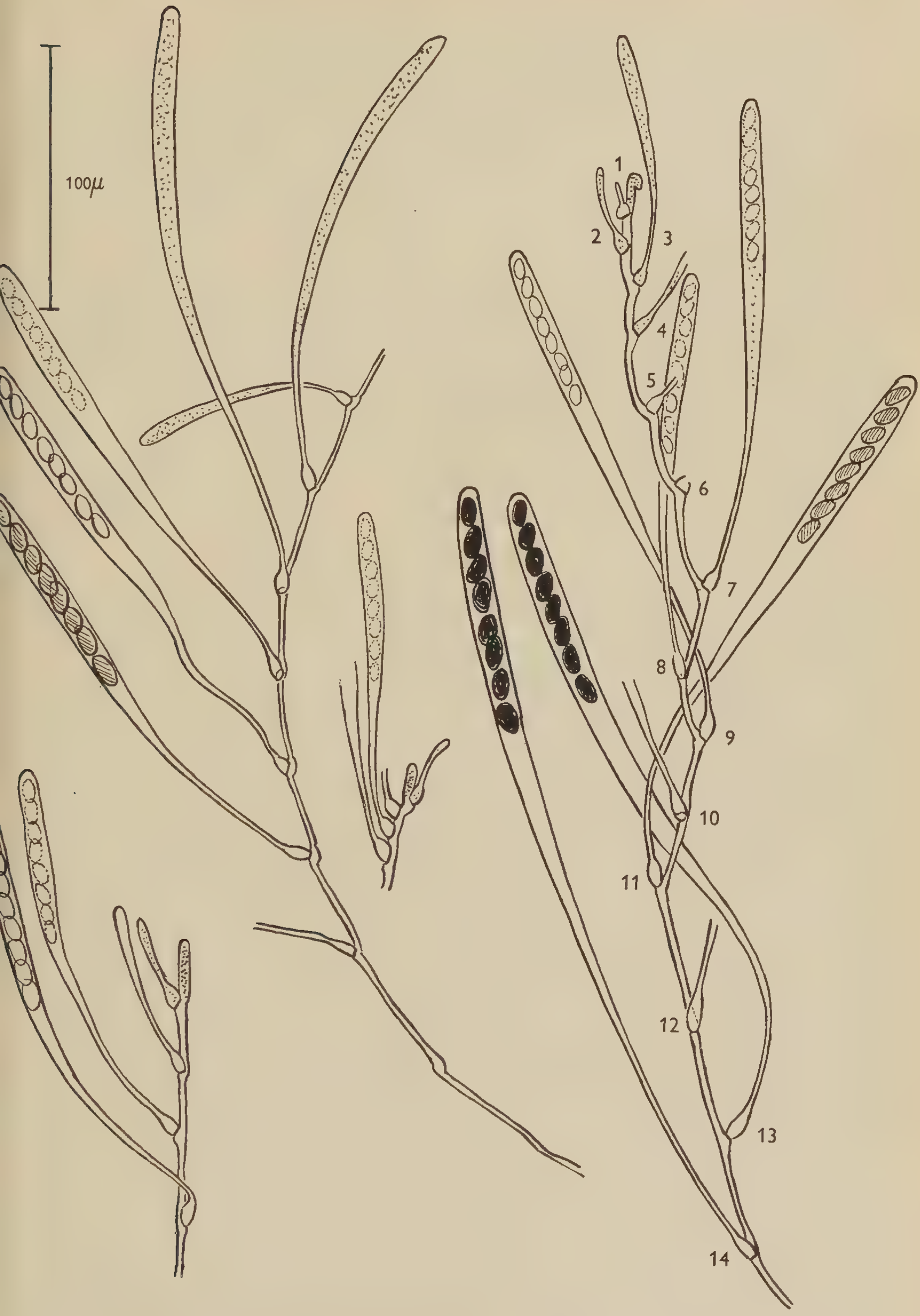

Fig. 1. Portions of ascogenous hyphae of *Daldinia concentrica* as seen in squash preparations of living perithecia. Drawn with aid of camera lucida.

elongation or is giving rise to an ascus, is filled with dense protoplasm. In the rest no contents are visible, although no doubt there is a thin lining layer of cytoplasm inside the wall.

Each ascus has a basal bulb, which represents the original ascus-initial cut off from the crozier of the ascogenous hypha, and from this a narrow stalk region grows out which gradually widens upwards as the spore-bearing part of the ascus is approached. It seems probable that it is by elongation of this stalk region that the ascus-tip finally reaches the ostiole at spore discharge.

Although no cytological details are known, this somewhat unusual type of ascogenous hypha would seem to give rise to asci in the conventional manner so frequently described, except that straight elongation of the hyphal tip may occur before each new crozier is formed. A diagrammatic interpretation is shown in Fig. 2. According to this the crozier is produced, and the penultimate ascus-initial cell is formed. The wall between the uninucleate ultimate cell and the hypha below the young ascus dissolves, and nuclear migration occurs so that the tip is again dikaryotic. Now, however, instead of this tip proceeding at once to crozier formation, it grows onwards maintaining the general direction of growth of the hypha as a whole, and only after a greater or lesser amount of elongation has occurred is the next crozier formed. As a result of this straight growth of the ascogenous hypha, the ascus is pushed into a lateral position.

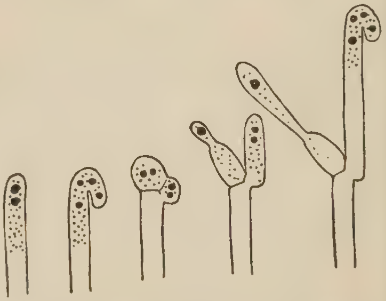

Fig. 2. Diagrammatic interpretation of the development of ascogenous hyphae in *Daldinia*.

It must be emphasized that each unbranched ascogenous hypha is really a single cell, often several hundred microns long, with its principal protoplasmic contents concentrated in its growing tip. In this respect it resembles a root hair, or a pollen tube growing through stylar tissue. It is of interest to consider the possible physiological implications of this structure. For the formation of each ascus relatively large quantities of material must reach the end of the ascogenous hypha, and its non-septate nature would presumably contribute to its efficiency as a channel of transport.

The cavity of the perithecium in *Daldinia* is not spherical but is rather elongated and tapers at its base into a conical depression containing the coiled archicarp. Presumably it is from this that the ascogenous hyphae arise, although, in squash preparations, it has not been possible to see the actual connexion. However, it is quite clear that the ascogenous hyphae arise from near the base of the perithecium and apparently grow up just inside the rigid perithecium wall, so that they form a kind of miniature basket. From these hyphae the asci arise, growing into the mucilage-filled cavity of the perithecium and pointing approximately towards the ostiole.

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FUNGAL PARASITES OF THE PHYTOPLANKTON. III*

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(With Plates 3–5 and 9 Text-figures)

Five new chytrids are described living on planktonic algae: *Rhizophidium uniguttulum* on *Gemellicystis neglecta* Teiling em. Skuja; *Rhizophidium difficile* on *Staurastrum jaculiferum* West and *Arthrodesmus* sp.; *Rhizophidium oblongum* on *Dinobryon divergens* Imhof and *D. stipitatum* Imhof; and *Zygorhizidium parallelosede* on *Ankistrodesmus* sp. and *Elakatothrix gelatinosa* Wille.

A description is given of the fungus recorded by Griffiths (1925) from the Cheshire Meres on akinetes of *Anabaena affinis* Lemm. var. *intermedia* Griffiths. It is tentatively placed in the genus *Rhizosiphon* as *R. akinetum* sp.nov.

New records of chytrids from Sweden from preserved collections of Drs G. Lohammar and A. Lundh are listed.

INTRODUCTION

Observations on the fungi which live on planktonic algae have now been made for five years in Windermere north and south basins, Blelham Tarn and Esthwaite Water. New hosts or substrata are still frequently discovered, but it seems probable that most of the organisms comprising this particular flora have now been seen. Several species have already been described (Canter, 1950, 1951; Canter & Lund, 1948, 1951, 1953), but the life histories of many more remain insufficiently known for publication. The other lakes in the Lake District which have been sampled regularly, but less frequently, during the past three years may not have yielded all their species, for with longer intervals between samples a fungus may easily be missed.

Several of the commoner fungi occur at about the same time each year, and it is possible to forecast approximately when to find a particular species in any one lake. For example, *Amphicypellus elegans* Ingold has been observed for the first time in the year on *Ceratium hirundinella* O.F.M. in Blelham Tarn on the following dates: 17 July 1947, 22 June 1948, 19 July 1949, 12 June 1950, 9 July 1951. In 1952 a specimen was found as early as 26 May, but the fungus did not occur regularly until 16 June. Again *Zygorhizidium melosirae* Canter was observed on *Melosira italica* (Ehrenb.) Kütz. in Esthwaite Water, 28 October 1946, 16 October 1947, 27 October 1948, absent in 1949, 2 October 1950, 30 October 1951, 29 October 1952. The period of duration of these two chytrids is comparatively long (*Amphicypellus elegans* from June to end of October in Windermere north and south basins, June to mid-September in Blelham Tarn, June to mid-October in Esthwaite Water, and *Zygorhizidium melosirae* from October to May in Blelham Tarn and Esthwaite Water). Other fungi seem to be sporadic in occurrence, although the algae on which they live are found for long periods in the plankton. Thus *Rhizosiphon crassum* Scherffel occurred in Loweswater on *Anabaena circinalis* (Kütz.) Hansg., only in June 1949 and June 1952, and although Esthwaite Water has been examined weekly for many years it was not until November 1951 that this particular fungus was observed there. Table 1 shows a similar sporadic occurrence of a chytrid (Pl. 3, fig. 3) which parasitizes *Coelosphaerium naegelianum* Unger. It seems unlikely that these fungi are in fact absent during certain years, but rather that they have occurred in numbers too small to be detected. These observations tend to indicate that, as in other plant associations, there are common and rare species of these fungi.

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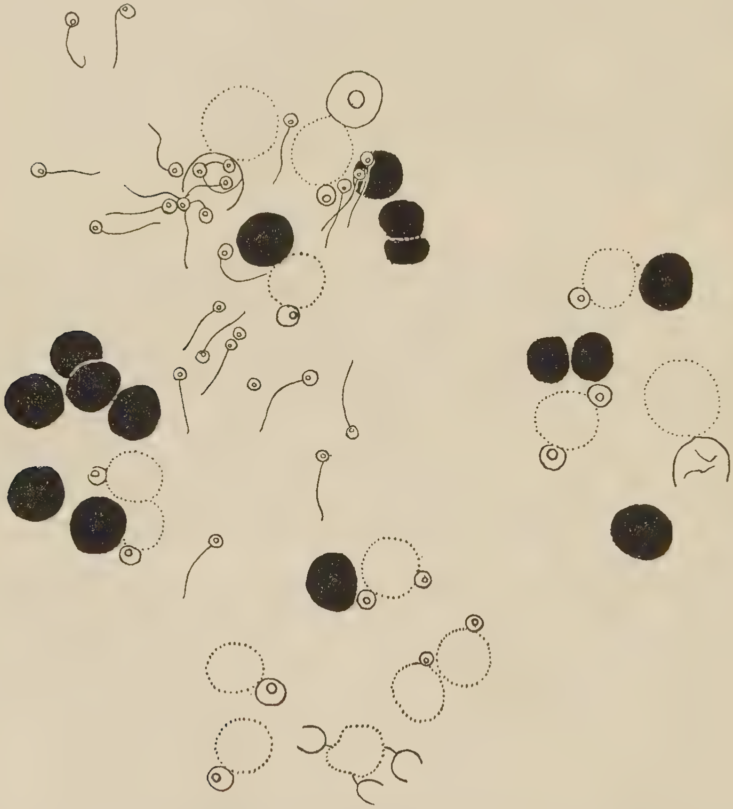
* Studies on British chytrids. XIII.

Table 1. *Seasonal occurrence of a chytrid on* Coelosphaerium naegelianum *in the Lake District*

Lake	1948	1949	1950	1951	1952
Loweswater	Mar., Dec.	Mar.–Apr.	No record	No record	No record
Crummock Water	No record	Jan.–May	No record	Feb.–Apr.	Feb.
Windermere south basin	No record	No record	No record	Mar.–Apr.	Apr.
Esthwaite Water	No record	No record	No record	Feb.–Apr.	Mar.



Text-fig. 1. *Rhizophidium uniguttulum* sp.nov. Heavily infected colony of *Gemellicystis neglecta.* Non-infected cells are blackened, the mucilage envelope surrounding the colony is not shown. × 730.

This group of fungi is not without its own fungal parasites, *Septosperma anomala* occurs on *Chytriomyces tabellariae* Canter (1949), *Rhizophidium sphaerocystidis* Canter (1950) and *Zygorhizidium planktonicum* (Canter & Lund, 1953). A species of *Rozella* has been found in chytrids parasitizing *Botryococcus braunii* in Malham Tarn, Yorks, and *Staurastrum* spp., Windermere and Loweswater; unidentified fungi on *Amphicypellus elegans* in Windermere, Esthwaite Water, Loweswater and Loughrigg Tarn, on *Rhizophidium fulgens*, in Hatch Mere, Cheshire (coll. E. M. Lind, 28 June 1942).

Rhizophidium uniguttulum sp.nov. (Text-figs. 1, 2; Pl. 3, figs. 1, 2)

Thallus monozentrisch, epibiotisch bestehend aus einem Sporangium und einem kleinen Rhizoidsystem, das gerade innerhalb der Wand der Wirtszelle liegt. Sporangium breit eiförmig, oval oder fast kugelig (3–13 μ breit; 4·5–15·5 μ hoch), direkt als eine Vergrösserung der Zoospore entwickelt; Entleerung mit Verschmelzung des Scheitels. Zoospore kugelig (2–2·5 μ im Durchmesser), mit einem einzigen, basalen, lichtbrechenden Tröpchen und mit einer hinteren Geissel (12 μ lang). Dauerspore nach Verschmelzung einer kleinen, männlichen Zelle mit einer ziemlich grösseren, weiblichen Zelle gebildet. Männliche Zelle (eine eingekapsulierte Zoospore) sitzt direkt auf der weiblichen Zelle, oder wird mittels eines kleinen Schlauches mit ihr vereinigt. Dauerspore kugelig (5·5–9·5 μ im Durchmesser), Wand glatt, dick mit einer gallertigen Hülle umgeben. Inhalt, ein grösseres und wenigere kleinen Tröpchen. Keimung nicht beobachtet.

Schmarotzend auf *Gemellicystis neglecta* (Teil.) Skuja im Plankton von Windermere (locus typus) und anderen Seen des englischen Seengegends.

Thallus monocentric epibiotic consisting of a sporangium and a meagre, branched rhizoidal system just within host cell-wall. *Sporangium* broadly ovoid, oval or globose, 3–13 μ broad and 4·5–15·5 μ high, developed by direct enlargement of the zoospore; dehiscing by deliquescence of the apex. *Zoospore* spherical, 2–2·5 μ in diameter, with a single basal refractive globule and posterior flagellum 12 μ long. *Resting spore* formed after sexual fusion of a small male cell (an encysted zoospore) which settles on and makes contact directly or via a short tube with a slightly larger female cell; spherical (5·5–9·5 μ) wall smooth, thick, surrounded by mucilaginous envelope; content one large and a few smaller globules. Germination not observed.

Parasitic on *Gemellicystis neglecta* Teiling em. Skuja in the plankton of Windermere (type locality) and other lakes in the English Lake District.

Rhizophidium uniguttulum (Text-fig. 1) is the third chytrid to be described as a parasite on *Gemellicystis neglecta* Teiling em. Skuja from the Lake District. (Its occurrence is shown in Table 2.)

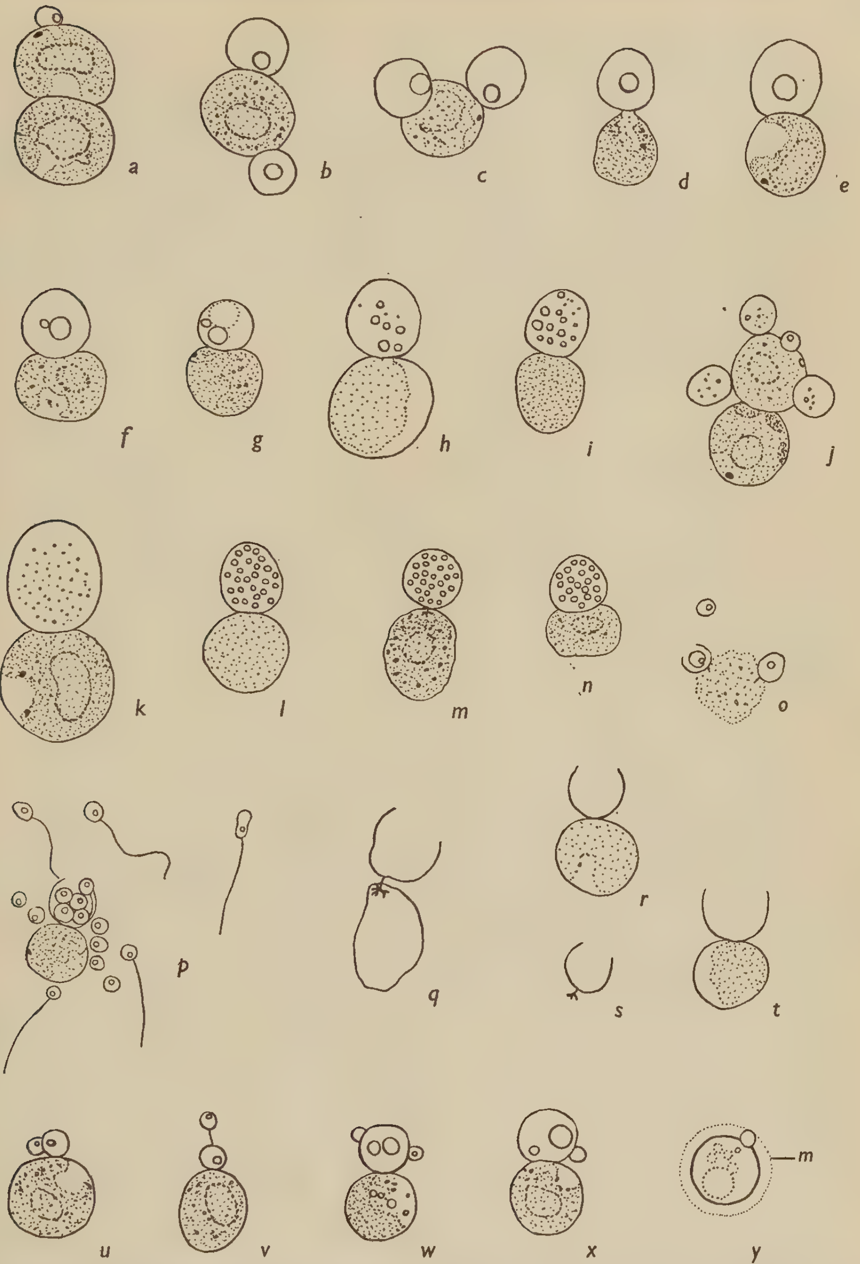
The spherical zoospore containing a single refractive globule settles on the surface of a host cell (Text-fig. 2*a*). In order to reach this position the zoospore has to traverse the wide mucilage envelope surrounding the *Gemellicystis* colony. It seems that the zoospore retains its flagellum while doing this, for flagellated zoospores are often seen within uninfected algal colonies. The sporangium is formed by direct enlargement of the zoospore. The changes in the content of the sporangium appear to be highly characteristic. As the sporangium grows the single refractive globule which was present in the encysted zoospore remains, and itself enlarges in size (Text-fig. 2*b–e* and Pl. 3, fig. 1). It seems that only when the sporangium has reached its full size do the protoplasmic changes recorded for most chytrids take place, eventually leading to the formation of numerous globules of equal size each indicating the position of a zoospore. The sporangia are broadly ovoid, oval or globose and contain from 8 to 30 zoospores (Text-fig. 2*l*–*n*). They vary in size, 5–13μ broad (measured at the widest point) and 6·5–15·5μ high. A few minute sporangia, 3–4μ broad, and 4–5μ high (Text-fig. 2*o*) containing from 1 to 4 zoospores have been observed. It is possible that these are products of zoospores which have alighted on host cells already bearing an earlier infection. The rhizoidal system is extremely meagre, consisting of a few short branches (Text-fig. 2*m*, *q*, *s*) just within the host cell-wall. The content of the alga becomes disorganized but retains its green colour. Only at a very late stage (probably some time after dehiscence of the sporangium) does the colour disappear and then the contents are reduced to a greyish mass of granules. It is only under these circumstances that the rhizoidal system becomes clearly visible. After deliquescence of a wide apical portion of the sporangium, the zoospores (2–2·5μ in diameter) emerge fully formed into the mucilage, but there still remains a long distance to be traversed before the external medium is reached. This is accomplished by slow spasmodic waves passing down the flagellum and by consequent jerking of the zoospore body. It may take half an hour for the zoospores to reach the outside, and once in a liquid medium they glide away with frequent changes of direction. The sporangium wall is delicate and eventually becomes almost invisible.

Table 2. *Occurrence of* Rhizophidium uniguttulum *on* Gemellicystis neglecta *Teiling em. Skuja from January* 1949–53

Lake	1949	1950	1951	1952
Blelham Tarn	10 Oct.	12 June, 6–30 Oct.	No record	No record
Esthwaite Water	22 Aug.–12 Sept.	24 July–14 Aug., 27 Nov.	No record	No record
Windermere south basin	5–12 Sept.	16–30 Oct.	13 Aug.–17 Sept.	26 May–1 Sept.
Windermere north basin	No record	10 Oct.–14 Nov.	27 Aug.–12 Nov.	3 June, 14 July–3 Nov.
Ullswater East	9–23 May	26 Apr., 24 May, 21 June	29 May	25 June, 20 Aug.
Ullswater West	28 Apr.	1–30 Mar.	29 May	25 June, 20 Aug.
Coniston Water	3 Oct.	No record	No record	No record
Bassenthwaite	No record	No record	23 May	22 Apr., 20 May, 19 June, 16 July

The resting spore is formed after fusion of a small male cell (essentially an encysted zoospore) which makes contact directly (Text-fig. 2*u*) or via a short tube (Text-fig. 2*v*) with a slightly larger female cell. At maturity the resting spore is spherical (5·5–9·5μ) with a smooth thick wall and contains one large and a few smaller globules (Text-fig. 2*y*). Surrounding the wall in the living state and just embracing the adherent, empty male cell is a zone of slime (?). It is amorphous and shows a slight affinity for aqueous methylene blue. Neither the rhizoids nor germination of the resting spore have been observed.

This fungus does not conform to any known existing species, thus it is described as new.



Text-fig. 2. *Rhizophidium uniguttulum* sp.nov. *a*, slightly enlarged zoospore. *b–e*, sporangia whose content still includes a single refractive globule. *f–i*, *k*, breakdown of the single globule and formation of numerous small globules. *j*, three small sporangia and a zoospore on a single host cell. *l–n*, mature sporangia. *o*, two minute sporangia with one and two zoospores; host content disorganized probably due to former infection, the empty sporangium of which is now invisible. *p*, dehiscing sporangium. *q–t*, empty sporangia; in *q* and *s* rhizoids visible. *u*, male cell directly attached to female. *v*, male cell connected to female via a fine thread. *w*, *x*, immature resting spores. *y*, mature resting spore in aqueous methylene blue showing halo of mucilage (*m*) and empty male cell. *q*, × 1330; others, × 930.

Rhizophidium oblongum sp.nov. (Text-fig. 3; Pl. 5, fig. 4)

Thallus monozentrisch, epibiotisch, in der Hülle einer Wirtszelle. Das Sporangium ist länglich bis oval (3–7μ breit, 7–24μ lang) oder fast kugelig (4·5–9μ breit; 5·5–9·5μ lang) und wird aus der Vergrösserung der Zoospore entwickelt. Das Rhizoidsystem besteht aus einer winzigen Hauptachse woraus ein Büschel von kleinen stabförmigen Zweigen entsteht. Bei der Entleerung löst die Sporangiumwand an einer oder beiden. Enden auf und wird, infolge seiner zarten Beschaffenheit, unsichtbar. Zoosporen, 2·5μ im Durchmesser, 20–60 pro Sporangium, wenn sie schwimmen, erscheinen sie oval, mit Geissel vornstehend aber rückwarts gerichtet, Öltropchen vorn. Dauerspore oval bis fast kugelig (5–9μ lang, 4–6μ breit) mit einer dicken, glatten Wand und innen mit mehreren kleinen Tröpchen. Dauersporenbildung nach Verschmelzung von Anisogameten; die männliche und weibliche Zellen direkt zusammen, oder mittels eines Kopulierungsschlauches (bis 5μ lang) gebunden. Keimung unbekannt.

Schmarotzend auf *Dinobryon* spp. im Plankton von gewissen europäischen Seen und in Blelham Tarn (locus typus), englischen Seengegend.

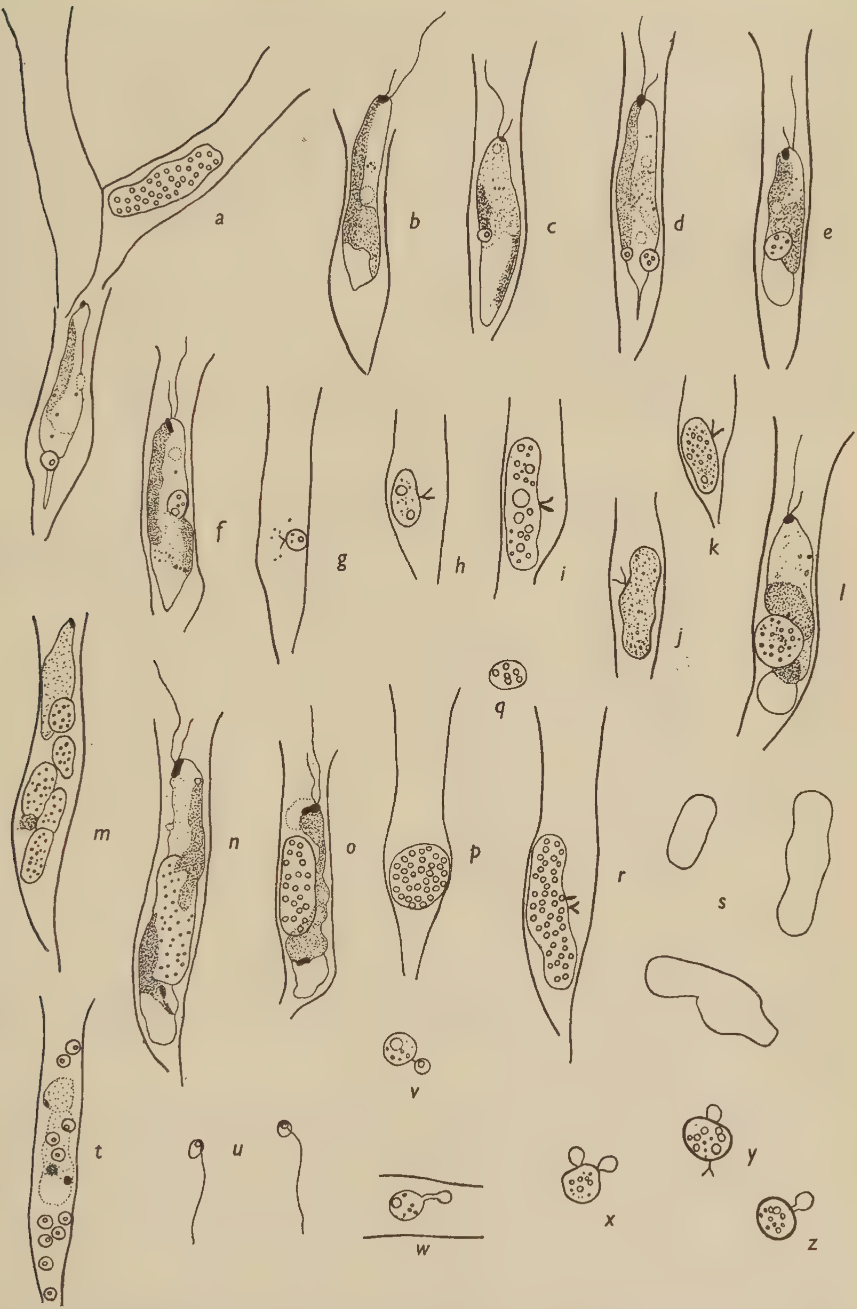
Thallus monocentric, eucarpic and epibiotic within the envelope of the host cell. *Sporangium* oblong to oval, 3–7μ wide and 7–24μ long, or subspherical 4·5–9μ wide and 5·5–9·5μ long, developed by enlargement of the zoospore. *Rhizoid* consisting of a minute main axis bearing a tuft of short rod-like branches. On dehiscence, sporangium wall dissolves at one or both ends and owing to its delicate nature becomes invisible. *Zoospores* 2·5μ (20–60 in a sporangium), oval when swimming with flagellum and oil globule anterior but former directed backwards. *Resting spore* oval to subspherical, 5–9μ long and 4–6μ broad, with a thick, smooth wall and containing several small globules. Resting spore formation preceded by fusion of unequal gametes; male attached directly or by means of a conjugation tube (up to 5μ long) to the female. Germination unknown.

Parasitic on *Dinobryon* spp. in the plankton of European lakes; type locality, Blelham Tarn, the English Lake District.

Also on *D. divergens* in Grisedale Tarn and Red Tarn in the Helvellyn Range and on *D. stipitatum* Imhof in Grasmere and Elterwater in the English Lake District; on *Dinobryon* sp. in preserved samples from Lago Mergozzo, Italy (coll. V. Tonolli, 24 September 1948); and from Krageholmsyjön, Sweden (coll. A. Lundh, 26 April 1949).

Some records of this parasite on *Dinobryon* are summarized in Table 3.

Cells of *Dinobryon* are very sensitive to changes in conditions and they die rapidly in the laboratory. When mounted under a cover-slip the naked protoplast soon passes out into the external medium leaving the parasite within the empty envelope of the *Dinobryon* cell (Pl. 5, fig. 4). The fungus occupies the space between the host protoplast and envelope, and is connected to the former by a few short rhizoids. It appears that in most cases death of the host does not occur until a late stage in fungal development. Cells containing a large immature sporangium may still possess active flagella and a contractile vacuole (Text-fig. 3*n*). Sometimes even the sporangium can grow to maturity and dehisce without killing the alga. This usually occurs when the fungus is located in the leucosin food reserve region of the algal cell. It may be that the chytrid is able to utilize this substance for its growth. In the early stages of infection of the algal population many cells of the same colony are attacked rather than isolated cells of different colonies. The spherical encysted zoospore is usually



Text-fig. 3. *Rhizophidium oblongum* sp.nov. *a*, part of a *Dinobryon* colony; one cell contains a mature sporangium the other a zoospore. Owing to pressure of the cover-slip the two upper envelopes are devoid of their cells. *b*, healthy host cell. *c*, zoospore. *d–l*, immature sporangia; *g–k*, rhizoids visible. *m*, *n*, sporangia in which oil globules of zoospores formed but not fully grown. *o–s*, mature sporangia; in *s*, oil globules of zoospores omitted. *t*, zoospores in algal envelope. *u*, free-swimming zoospores. *v*, *w*, early stages in development of resting spore. *x*, resting spore with two male cells. *y*, *z*, mature resting spores. All, × 825.

located in the mid-region or towards the posterior end of the host cell (Text-fig. 3*a*, *c*). How the zoospore reaches this position is unknown. It enlarges and at first retains its spherical shape and single refractive globule. In the majority of specimens further growth involves elongation in a direction parallel to the long axis of the host cell (Text-fig. 3*h*–*k*). The sporangium may be sausage-shaped, oblong-oval, or more rarely subspherical. The variation in form is shown in Text-fig. 3*o*–*s*. Oblong-oval and sausage-shaped sporangia vary in size, 7–24μ long and 3–7μ wide; subspherical sporangia, 4·5–9μ long and 5·5–9·5μ wide. Up to six sporangia have been found on one algal cell. The mature sporangium contains from twenty to sixty refractive globules, each indicating the position of a zoospore. Dehiscence has not been seen, but envelopes of *Dinobryon* containing recently liberated zoospores are frequently found (Text-fig. 3*t*). The zoospore (when spherical) is 2·5μ in diameter with a single refractive globule located at the point of insertion of the flagellum.

Table 3. *Occurrence of* Rhizophidium oblongum *on* Dinobryon divergens *Imhof from January* 1949–53

Lake	1949	1950	1951	1952
Blelham Tarn	9 May–9 June	1 May–5 June	17 May–2 July 3 Sept.–30 Oct.	12–19 May, 14–28 July, 8 Sept.
Windermere south basin	30 May	30 May–19 June	No record	26 May–16 June
Windermere north basin	17–31 May	30 May	No record	19–26 May
Elterwater	21 Apr., 11 May, 10 June	10 May	28 May	15 May–12 June
Grasmere	No record	10 May	28 May	15 May–11 June
Rydal Water	No record	6 June, 30 Sept.	28 May	15 May
Loughrigg Tarn	28 Apr.	5 Sept.	No record	9 July, 7 Aug.
Coniston Water	No record	12 July, 8 Aug.	No record	No record
Esthwaite Water	No record	No record	No record	26 May–10 June
Derwentwater	No record	No record	No record	18 June–13 Aug.

When swimming, the zoospore is oval and the flagellum and oil globule seem to be anterior in position with the flagellum directed posteriorly (Text-fig. 3*u*). Owing to the small number of motile zoospores which have been observed further investigations are necessary to substantiate this point.

No empty sporangium has ever been detected in the living material, and it seemed likely that total dissolution of the wall occurs on dehiscence. However, if the material is stained with gentian violet in aniline water the exceedingly delicate walls are revealed. It seems that quite a large area may dissolve at one or both ends of the sporangium. I have found rhizoids, apparently floating in the host envelope, but, after applying the stain, the empty sporangium to which they are in fact attached is made visible. The rhizoidal system is very sparse and takes the form of short, blunt refractive rod-like branches arising from a minute main axis. The latter can only be detected in specimens where dehiscence has taken place, and the rhizoid which retains its refractive nature becomes clearly visible in the envelope of the *Dinobryon* cell. Usually the rhizoid arises from the middle of the sporangium (Text-fig. 3*g*–*i*), but in smaller specimens it may occur towards one end. The position of the rhizoid in the mid-region of an elongate sporangium suggests that it is formed by bilateral expansion of the encysted zoospore. The resting spore (Text-fig. 3*x*–*z*) is oval to subspherical and is produced after sexual fusion. The fusing bodies seem to be unequal (Text-fig. 3*v*, *w*). The male may either be attached directly or by a conjugation tube, up to 5μ long, to the female. The rhizoids of the latter where visible resemble those of the sporangium. The mature resting spore, 4–6μ broad and 5–9μ long, contains several small globules and has a smooth thick wall bearing the empty male cell. This fungus in the main resembles species of the genus *Rhizophidium*. If subsequent observations confirm the anterior attachment of the flagellum, then in this respect the zoospore resembles that found in *Olpidiomorpha* and *Sphaerita*. However, for obvious reasons, the fungus could not be included in either of these genera. It is placed in the genus *Rhizophidium* as a new species *R. oblongum*.

Rhizophidium difficile sp.nov. (Text-figs. 4, 5; Pl. 3, fig. 4)

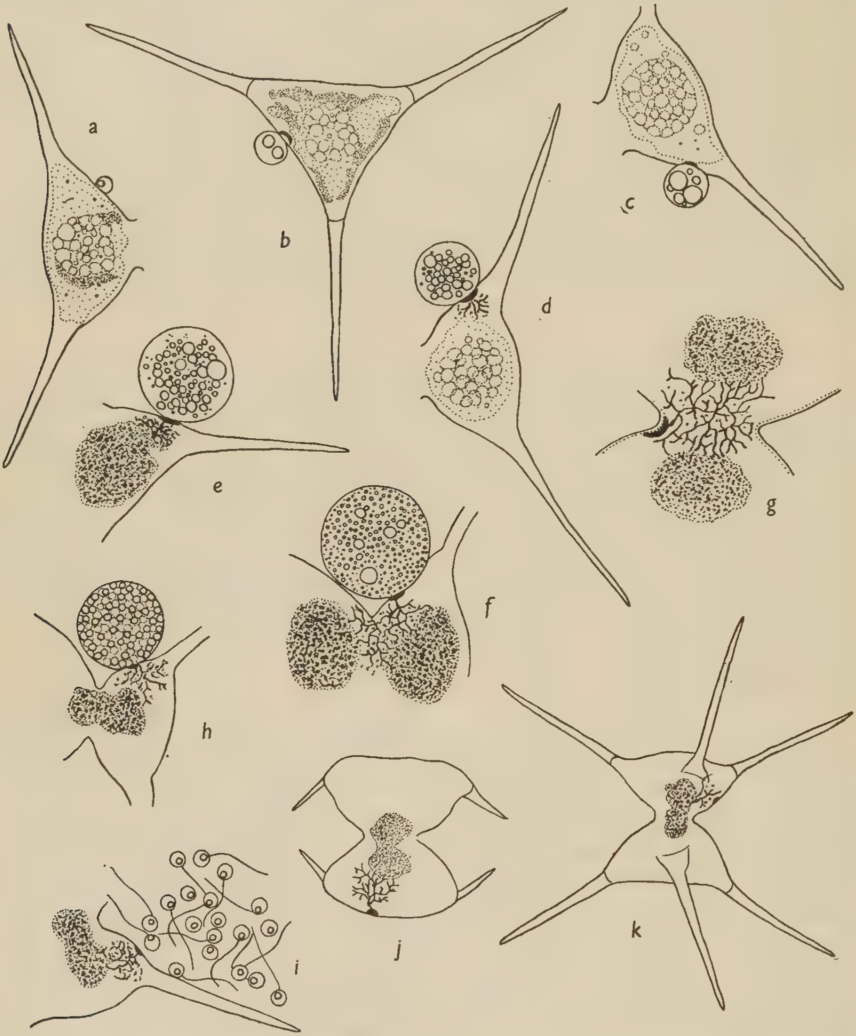
Thallus monozentrisch, aus einem epibiotischen, kugeliförmigen Sporangium (12–20μ im Durchmesser) bestehend, aus einer Vergrösserung der Zoospore und aus einem kurzen, verzweigten, komplizierten Rhizoidsystem entstanden. Die gesamte Sporangiumwand löst sich bei der Entleerung auf, um bis auf 90 Zoosporen zu befreien. Zoospore kugelig (2·5μ im Durchmesser), mit einem grossen, hinteren Tröpchen und eine Geissel (12μ lang); reguläre gleitende Bewegung. Dauerspore (8–13·6μ im Durchmesser) kugelig, nach Verschmelzung einer kleinen, männlichen mit einer grösseren, weiblichen Zelle gebildet. Die männliche klebt direkt an der Wand der weiblichen Zelle. Die dicke, glatte, braunliche Wand entweder ist umringt oder bedeckt mit Fäden von gallertähnlichen Material. Inhalt, viele, kleine Tröpchen. Das Rhizoidsystem ist identisch mit demjenigen des Sporangiums. Keimung unbekannt.

Schmarotzend auf *Staurastrum jaculiferum* W. West im Plankton von Windermere (locus typus), englischen Seengegend.

Thallus monocentric, eucarpic, consisting of an epibiotic spherical sporangium formed by enlargement of the zoospore and a complicated branched endobiotic rhizoidal system of limited extent. *Sporangium* (12–20μ in diameter) containing up to ninety zoospores. Entire wall of sporangium dissolves on dehiscence. *Zoospore* spherical 2·5μ in diameter, with a large posterior globule (1–1·35μ), and a flagellum 12μ long; movement smooth gliding. *Resting spore* spherical (8–13·6μ in diameter) formed after fusion of a small male with a larger female cell. Male directly adherent to wall of female. Wall thick, smooth, brownish, surrounded by a halo or beset with strands of mucilaginous (?) material; content numerous small globules. Rhizoidal system as for sporangium; germination unknown.

Parasitic on *Staurastrum jaculiferum* W. West, in the plankton of Windermere (type locality), the English Lake District.

This fungus has been found as a parasite on *Staurastrum jaculiferum* W. West in Windermere, occurring in the months September to January, and on *Arthrodesmus* sp. in Bassenthwaite Lake, December 1951. The following description is based entirely on the Windermere material. The fungus may occur on any part of the host cell, but usually on the lateral wall near the base of a spine (Text-fig. 4*c*–*e*). No more than two individuals of the parasite have been observed on a single desmid cell. The zoospore apparently passes through the mucilage surrounding the alga and settles on its wall where the sporangium is formed. The zoospore enlarges directly into a spherical sporangium. During development, the sporangium is crowded with refractive material. When the zoospores are fully delimited they cause a bulging of the sporangium wall which in consequence has a wavy appearance in optical section. In young stages the rhizoidal system is invisible, but as the sporangium grows the host chloroplast shrinks and the rhizoid is seen between the latter and the host wall.



Text-fig. 4. *Rhizophidium difficile* sp.nov. *a*, zoospore. *b–f*, immature sporangia. *g*, much branched rhizoidal system. *h*, mature sporangium. *i*, zoospores. *j*, *k*, infected host cell after dissolution of sporangium wall and disappearance of the zoospores; *j*, *Arthrodesmus* sp., *k*, *Staurastrum jaculiferum*. *k*, × 625; *g*, × 1450; others, × 825.

The rhizoidal system, though not extensive, is highly complicated and difficult to depict (see Text-fig. 4*g* and Pl. 3, fig. 4). It is only possible to give a pictorial representation of it with the help of a camera lucida. The rhizoidal system does not appear to ramify through the remains of the host content which usually consists of one or two shrunken reddish masses.

The sporangia vary in size (12–20μ in diameter) and may contain as many as ninety zoospores. When the sporangium is about to dehisce its wall becomes thinner and more difficult to see. At first dissolution of the wall seems to occur at one point, and in consequence a few zoospores are liberated quickly. The remainder soon spread out on all sides, the entire wall having dissolved.

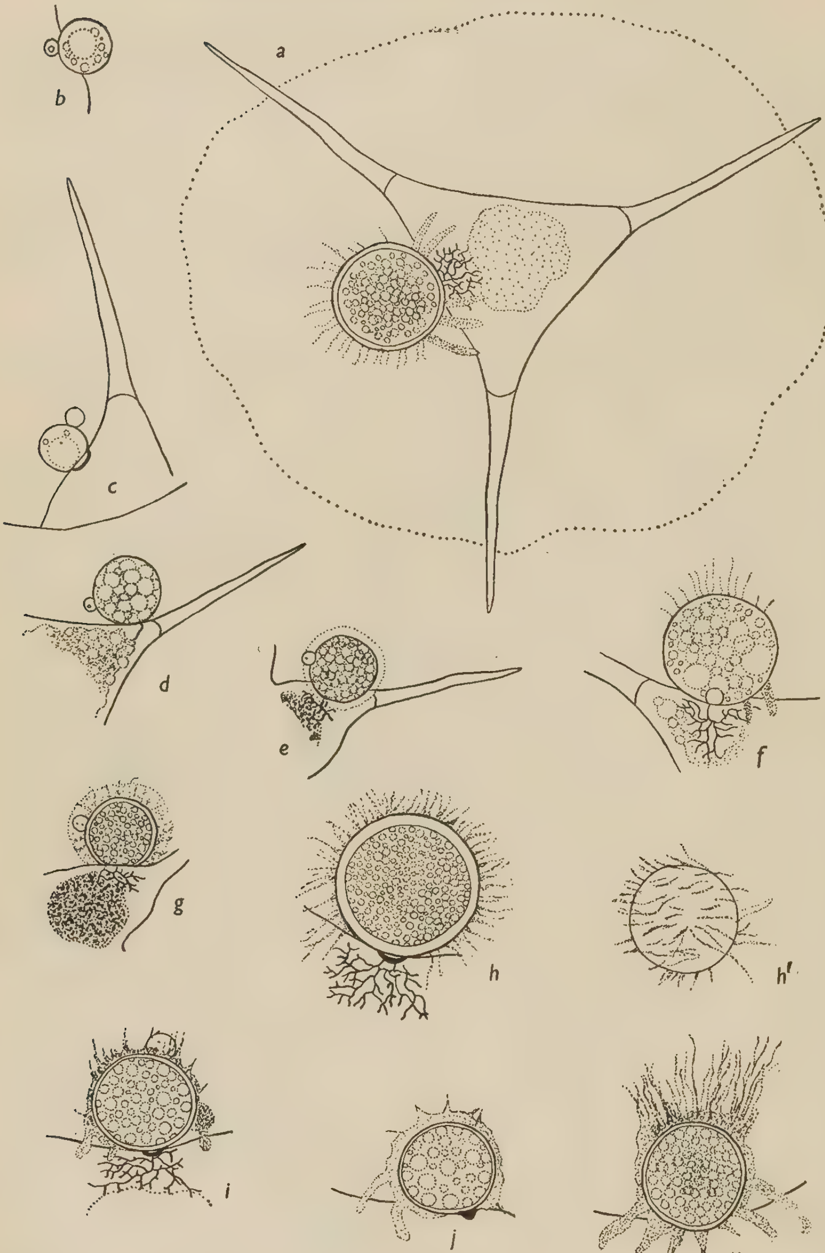
The zoospore (Text-fig. 4*i*) is spherical 2·5μ in diameter with a single large posterior globule (1–1·35μ) and a flagellum 12μ long; its movement is smooth, even gliding.

Although no empty sporangium remains, individuals of *Staurastrum jaculiferum* which have been infected by this fungus, can easily be distinguished by the following characters: (*a*) reddish colour of the host content, (*b*) clearly visible rhizoidal system, (*c*) a slight thickening of the desmid wall which usually occurs at the point of infection (Text-fig. 4*d*–*g*).

The earliest stage observed in the sexual process leading to the formation of a resting spore is shown in Text-fig. 5*b*, *c*. From this it seems likely that the male cell (essentially an encysted zoospore) makes direct contact with a larger female one. The resting spore, like the sporangium, is spherical but smaller in size (8–13·6μ in diameter); its rhizoidal system is also similar (Text-fig. 5*h*). The mature spore has a thick smooth, brownish wall and the content consists of numerous small refractive globules. On the outer surface of the spore is a colourless (mucilaginous ?) substance which appears either as strands or as a complete halo. The strands on the side adjacent to the desmid wall are often thicker and seem to cement the spore to its host (Text-fig. 5*a*, *f*, *k*). In young resting spores before a halo or strands of 'mucilage' are visible a spherical area can be stained by methylene blue (Text-fig. 5*e*). It is thought that these strands are secreted by the fungus and are not the altered mucilage of the host cell. When the resting spore is mature the empty male cell may be difficult to find, being hidden in the mucilaginous secretion. This chytrid presents no very unusual features except for the method of dehiscence of the sporangium. Dehiscence by total dissolution of the wall has already been recorded for *Hapalopera piriformis* Fott, *Nowakowskia hormothecae* Borzi, *Rhizophidium achnanthis* Friedmann, *R. melosirae* Friedmann, *R. sphaerocystidis* Canter and *Solutoparies pythii* Whiffen. I do not consider that this character is alone worthy of generic distinction (cf. Friedmann, 1952), therefore, since this fungus resembles in all other respects species of the genus *Rhizophidium*, I place it in that genus and the name *R. difficile* is proposed.

Rhizosiphon akinetum sp.nov. (Text-figs. 6, 7; Pls. 4, 5, figs. 1–3)

Das endobiotische Prosporangium ist oval bis länglich-oval (8·6–23μ lang, 5–11μ hoch) und entsteht als eine Anschwellung auf der Spitze des Zoosporenkeimschlauches. Sporangium ohne Deckel (?), von verschiedener Gestalt, kugel- oder zitronenförmig (8–20μ hoch, 6–8μ breit). Obere Hälfte des Sporangiumwands dick und mit kurzen,



Text-fig. 5. *Rhizophidium difficile* sp.nov. *a*, *Staurastrum jaculiferum* mounted in indian ink to show the surrounding mucilage sheath in which a resting spore of *Rhizophidium difficile* is embedded. *b*, *c*, early stages in resting spore formation. *d*, young resting spore, no indication of mucilaginous secretion. *e*, beginning of mucilage, although scarcely visible to the naked eye. *f*, immature resting spore with mucilaginous threads. *g*, *h*, *i*–*k*, mature resting spores with various types of mucilage envelopments; *h′* as *h* less magnified and showing mucilage threads on the surface of the resting spore. *b*–*g*, *i*, male cells visible; *d*, *e*, *g*–*k*, mounted in water with aqueous methylene blue. *a*, *c*, *f*, × 650; *b*, *d*, *e*, *g*, × 825; *h′*, *j*, × 1050; *h*, *i*, *k*, × 1450.

stabförmigen Zeichnungen bedeckt. Die leere Hülle der Zoospore bleibt an der Dauerspore des Wirtes klebend oder wird auf die Sporangiumwand aufgehoben. Zoospore 2·5–3μ im Durchmesser, Inhalt körnig mit mehreren, winzigen, lichtbrechenden Tröpchen. Dauersporenbildung gescheiht nach der Verschmelzung von Isogameten, eine von denen früher als das andere zur Rühe gekommen ist und auch (?) gekeimt hat. Dauerspore endobiotisch, oval bis länglich—oval (8–26μ lang; 7–16μ hoch), mit einer dicken, glatten, zweischichtigen Wand und einem einzigen oder wenigen, grossen Tröpchen. Ein Dreieck von stark, lichtbrechendem Material entsteht an der Berührungstelle eines verdickten Fadens und der Dauerspore selbst. Gekeimte Dauerspore verwandelt sich direkt in einer Sporangium.

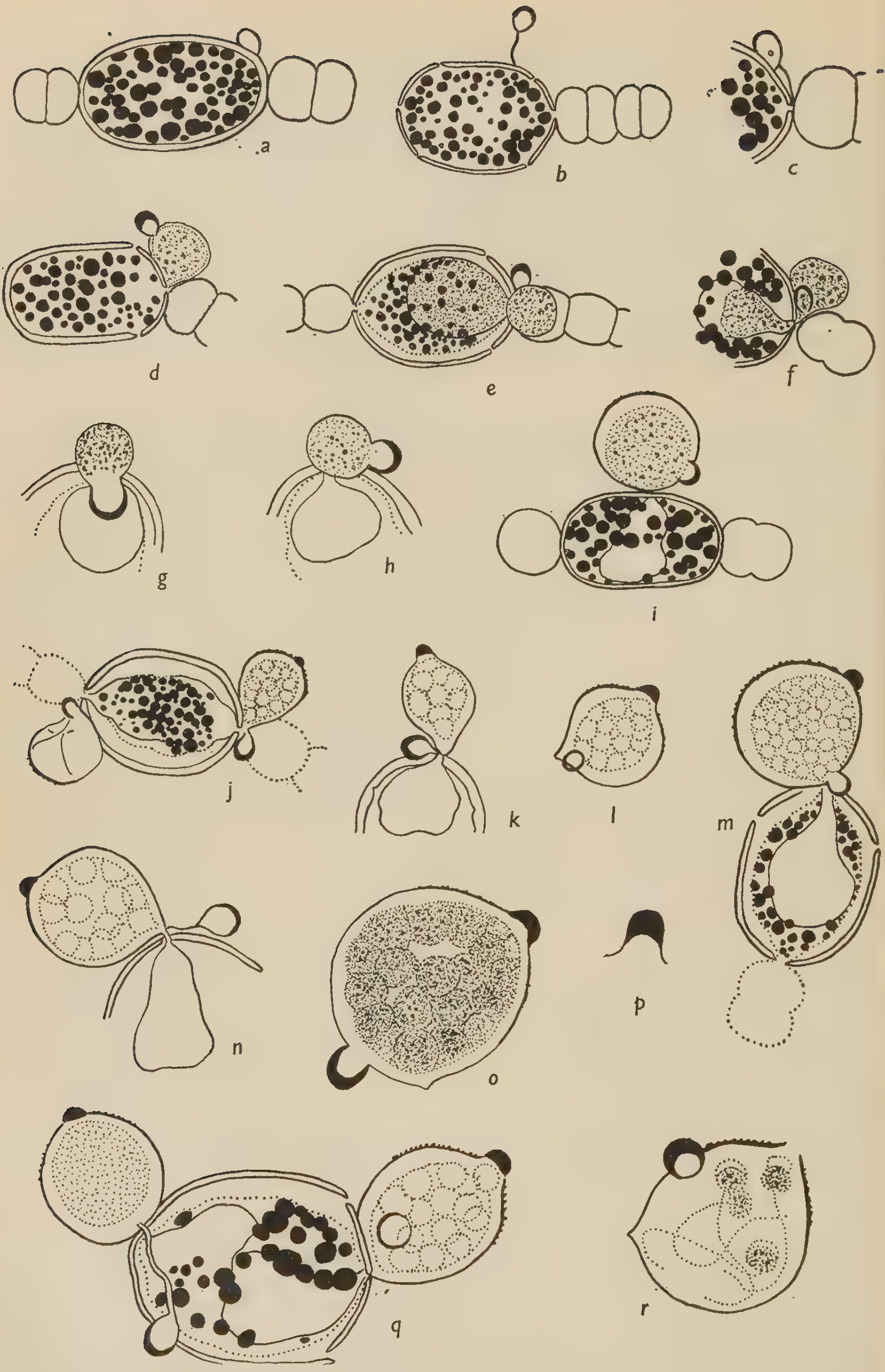
Schmarotzend auf Dauersporen von *Anabaena affinis* Lemm. var. *intermedia* Griffiths im Plankton von Blake Mere (locus typus), Kettle Mere and White Mere, Cheshire, England.

Thallus endobiotic, prosporangium oval to elongate-oval, 8·6–23μ long and 5–11μ high, arising as a swelling from the tip of the germ tube of the zoospore. *Sporangium* inoperculate (?) variable in shape, spherical or limoniform, 8–20μ high and 6–8μ broad, with a conspicuous papilla up to 2μ high. Distal half of sporangium wall thick and covered with short rod-like markings. Empty zoospore case remaining on akinete or carried up on wall of sporangium. *Zoospore* 2·5–3μ in diameter, content granular with several minute refractive globules. *Resting spore* formation preceded by fusion of isogamous gametes, one of which had previously come to rest and (?) germinated. Resting spore endobiotic, oval to elongate oval, 8–26μ long and 7–16μ high, with a thick smooth two-layered wall; content one or a few large globules. A triangle of highly refractive material occurs at the point of contact of the thickened thread from the gametes and the resting spore itself. Resting spore directly transformed into sporangium on germination.

Parasitic on akinetes of *Anabaena affinis* Lemm. var. *intermedia* Griffiths, in the plankton of Blake Mere (type locality), Kettle Mere, and White Mere, Cheshire, England.

Griffiths (1925) records the presence of a fungus attacking gonidia of *A. affinis* Lemm. var. *intermedia* Griffiths from Kettle Mere, Blake Mere and White Mere, Cheshire, England, but no details are given. I have examined his material (preserved in formalin), and it is now possible to give some description of the fungus concerned. Again, Dr B. Fott sent me drawings of a fungus in akinetes of *A. macrospora* Kleb. collected on 20 July 1951 in a pond near Sedlice, South Bohemia, Czechoslovakia. Examination of preserved material he kindly sent me enabled me to confirm its identity with the British material.

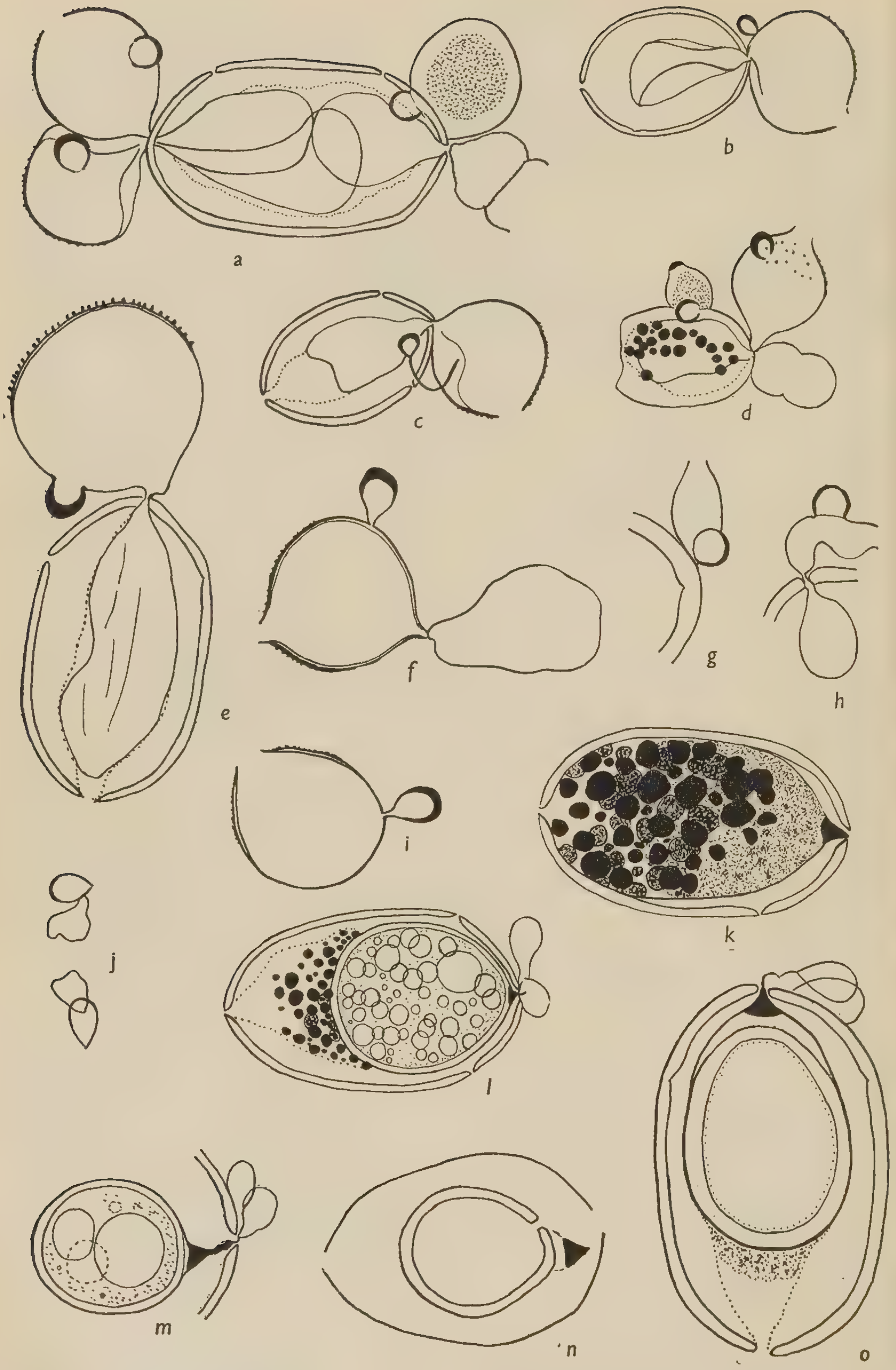
The chytrid appears to be limited to the fully grown thick-walled oval akinetes; young spherical ones are never infected. In most instances the zoospore settles on the wall of an akinete close to the pore which connects it to the neighbouring vegetative cell (Text-fig. 6*a*; Pl. 4, fig. 1). Rarely, the zoospore settles in a more central position (Text-fig. 6*i*) on the wall or in the mucilage surrounding the akinete (Text-fig. 6*b*). The zoospore produces a fine thread which enters the akinete via the pore. This thread varies in length according to the distance of the zoospore from the pore. Inside the akinete and continuous with this thread a sac-like swelling is formed. The early stages in the development of this sac are impossible to



Text-fig. 6. *Rhizosiphon akinetum* sp.nov. *a*, empty encysted zoospore on akinete of *Anabaena*. *b*, zoospore which has encysted in the mucilage surrounding an akinete. *c*, zoospore with germ thread to terminal pore of akinete. *d–f*, early stages in sporangial development; prosporangium visible in *e*, *f*. *g*, *h*, minute immature sporangia. *i*, sporangium which has developed in central position on lateral wall of akinete. *j–o*, mature sporangia; content of zoospores shown in *o–p*, dehiscence papilla, appears highly refractive in the preserved state. *q*, a mature and immature sporangium, the latter separated from persistent zoospore case by a long thread. *r*, dehisced sporangium with zoospores. *c*, × 1100; *g*, *h*, *n*, *q*, *r*, × 1400; *o*, *p*, × 1600; others, × 1000.

observe owing to the numerous refractive globules present in the akinete. During the growth of the sac the apex of the now empty encysted zoospore thickens and becomes highly refractive; the protoplast membrane shrinks and the globules of the akinete become less numerous. It is now that the sac containing dense whitish protoplasm becomes clearly visible. The sac varies, 8·6–23 μ long and 5–11 μ wide, and behaves as a prosporangium. No rhizoidal system has been observed connected to the prosporangium. Later the content from the prosporangium emerges via the pore where entry into the akinete was accomplished, to form a sporangium. According to the position of the empty zoospore case it may be either carried up on the wall of the developing sporangium (Text-fig. 7*e–f*) or remain attached to the wall of the akinete (Text-fig. 6*n*, *q*; Pl. 4, fig. 2). During the development of the sporangium a portion of the wall (apical or lateral) bulges slightly to form a highly refractive papilla (Text-fig. 6*k–p*). In the several sporangia which I observed with differentiated zoospores this papilla was a prominent feature. If a mature sporangium is stained with gentian violet in aniline water, the papilla takes on a deep red coloration, whereas the wall and empty zoospore cyst remain colourless. Thus it seems likely that the papilla is mucilaginous and dissolves on dehiscence. Similarly, Dr B. Fott (personal communication, 1951) does not believe that the papilla becomes an operculum. The sporangia vary considerably in shape and as many as four have been seen on a single akinete. Some sporangia resemble lemons tapering basally towards the prosporangium and distally towards the papilla (Text-fig. 6*k*), others are more spherical (Text-fig. 6*n*). They vary in size, 8–20 μ high (excluding papilla up to 2 μ high) and 6–8 μ broad, measured in the mid-region. The wall of the sporangium appears thicker in its distal half where it is usually rough, due to the presence of short rod-like structures (Text-figs. 6*m*, *q*, *r*; 7*c*, *e*; Pl. 4, fig. 3). At first these were thought to be epiphytic bacteria, but as they are present on nearly every sporangium (except very small ones) it is believed that they represent characteristic markings. The zoospore (2·5–3 μ in diameter) lacks the single globule found in most chytrids, its content is granular with several minute highly refractive globules. The empty sporangium does not collapse after dehiscence.

The resting spore is formed within the akinete and it seems likely that a sexual process is involved. When young, the resting spore cannot be distinguished from a prosporangium except for the fact that it is connected to two empty (?) gametes (resembling encysted zoospores) just outside the terminal pore of the akinete (Text-fig. 7*j*, *k*; Pl. 4, figs. 1, 2). At what stage in development these two gametes make contact is unknown. Their walls remain thin and do not thicken as does the empty encysted zoospore case connected to the sporangium. In the early stages the resting spore has a thin wall and densely granular content. Later the wall thickens and consists of an outer refractive layer and an inner wider non-refractive layer. Within this is the content consisting of one or a few large globules. The resting spore varies in shape from oval to elongate oval, 8–26 μ long and 7–16 μ broad. Some spores contain large vacuolate areas, but whether they are produced as a result of fixation or not is unknown. A striking feature of the resting spore is the triangular highly refractive area produced



Text-fig. 7. *Rhizosiphon akinetum* sp.nov. *a*, three sporangia with endobiotic prosporangia. *b–i*, empty sporangia showing various positions of the empty zoospore case; *g*, *h*, minute sporangia. *j*, two views of gametes (?) associated with a resting spore. *k*, *l*, immature resting spores. *m–o*, mature, *n*, (?) germinated resting spores. For explanation of (*w*) and (*s*) see text (p. 127). *b–d*, × 1000; *a*, *f–j*, × 1400; *c*, *k–n*, × 1660; *o*, × 1780.

at its point of contact with the thickened thread arising from the supposed gametes (Text-fig. 7*k*–*m*; Pl. 5, fig. 3 (*t*)). This area in time is shut off from the rest of the spore by the development of an internal septum (Text-fig. 7*o* (*s*)). This internal septum actually forms part of the outer wall of the mature spore which by its development becomes symmetrically shaped at both ends. It seems that the portion of wall designated (*w*) in Text-fig. 7*o* soon disintegrates. One empty resting spore was found where the triangular material had been displaced to one side and there was a small circular pore in the wall (Text-fig. 7*n*). No structure resembling an empty sporangium could be found; thus it is possible that if this really was a germinated resting spore it behaves directly as a sporangium and the zoospores are liberated through the pore.

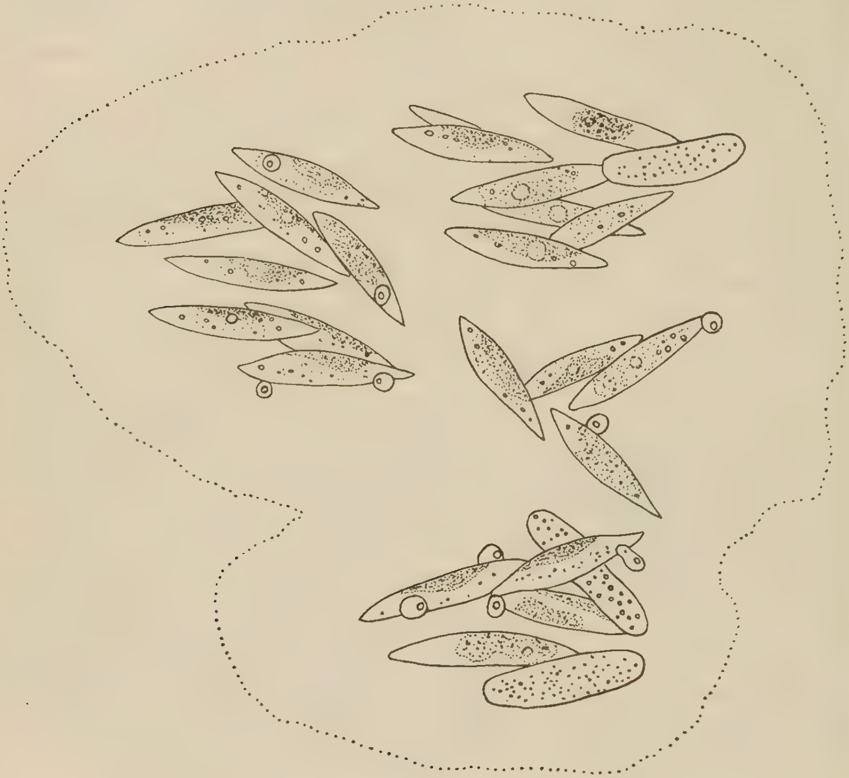
It is difficult to discuss the affinities of this fungus due to the lack of details concerning dehiscence. In its general life history it seems most nearly allied to species of *Rhizosiphon* (Canter, 1951). In these fungi the sporangium is formed as a direct outgrowth from the prosporangium which is sac-like and bears no rhizoids. There is a prominent mucilaginous papilla and the resting spore is formed from the endobiotic swelling after similar sexual fusion. At first sight among the operculate fungi it appears to resemble *Chytridium schenkii* Scherffel, *C. aggregatum* Karling, *C. oedogonii* Couch, and others where a part of the zoospore case persists as a protuberance on the sporangium wall. In these fungi the sporangium is budded out laterally from the zoospore cyst. In the fungus under consideration I believe that the sporangium develops as a direct outgrowth from the prosporangium and that according to the length of the original germ thread which in most cases varies according to the distance of the encysted zoospore from the pore of the akinete, the zoospore case may (Text-fig. 7*e*, *f*; Pl. 2, fig. 4) or may not (Text-fig. 6*n*, *q*; Pl. 2, fig. 2) be carried up on the sporangium. Although this fungus exhibits endo-exogenous development the zoospore case does not participate in the formation of the sporangium as in *Chytridium lagenaria* Schenk *pro parte* and certain species of *Phlyctochytrium*. There is no doubt that a new species is involved, but that the generic position cannot be definitely decided until more is known concerning the method of dehiscence. For the present I place it in the genus *Rhizosiphon*, as *R. akinetum*.

Zygorhizidium parallelosede sp.nov. (Text-figs. 8, 9; Pl. 5, figs. 5, 6)

Thallus monozentrisch. Das Sporangium entwickelt aus einer eingekapselten Zoospore und ist entweder breit zylindrisch bis zigarrenförmig (3–6μ hoch; 8–26μ lang) oder länglich bis oval (3–4μ hoch; 4–5·5μ lang). Zoosporen 4–40, voll gebildet vor der Entleerung, kugelig (2μ im Durchmesser, Geissel hinten, 11μ lang) mit einem einzigen seitlichlen bis basalen Tröpchen, und mit graulichem Protoplasma, das einige winzige Körnchen enthält. Das Sporangium entleert sich mittels eines Deckels und fällt nicht nach die Entleerung ein. Das Rhizoidsystem besteht aus einem schwach oder wenig verzweigten Faden. Dauerspore geschlechtlich gebildet. Männliche und weibliche Zellen (2–3·5μ breit, 2–6μ lang) sind oval bis länglich oval und besitzen Fäden. Männliche Zelle mittels eines Kopulationsschlauches (bis auf 16μ lang) mit der weiblichen Zelle kopulierend. Reife Dauerspore länglich oval (5·5–17μ lang; 3–6μ hoch). Wand dick, glatt, farblos; Inhalt ein einziges grosses Tröpchen. Keimung unbekannt.

Schmarotzend auf *Ankistrodesmus* sp. im Plankton von Windermere (locus typus) und anderen Seen des englischen Seengegends.

Thallus monocentric, eucarpic sporangium developed from body of an encysted zoospore. Rhizoid a fairly thick unbranched or little branched thread. *Sporangium* broadly cylindrical to cigar shaped, 3–6 μ high and 8–26 μ long; oblong to oval, 3–4 μ high and 4–5·5 μ long; operculate, not collapsing after dehiscence. *Zoospores* 4–40, fully formed in the sporangium, spherical (2 μ in diameter, posterior flagellum 11 μ long), with a latero-basal globule and greyish protoplasm with a few minute granules. *Resting spore* sexually formed. Male oval to elongate oval (2 × 3·5–2 × 6 μ) makes contact with a female of more or less similar size by means of a conjugation tube up to 16 μ long. Resting spore elongate oval, 5·5–17 μ long and 3–6 μ high. Wall thick, smooth, colourless, content when mature a single large globule. Both male and female bearing rhizoids. Germination unknown.



Text-fig. 8. A colony of *Ankistrodesmus* sp., with zoospores and sporangia of *Zygorhizidium parallelosede* sp.nov. × 930.

Parasitic on *Ankistrodesmus* sp. in the plankton of Windermere (type locality) and other lakes in the English Lake District.

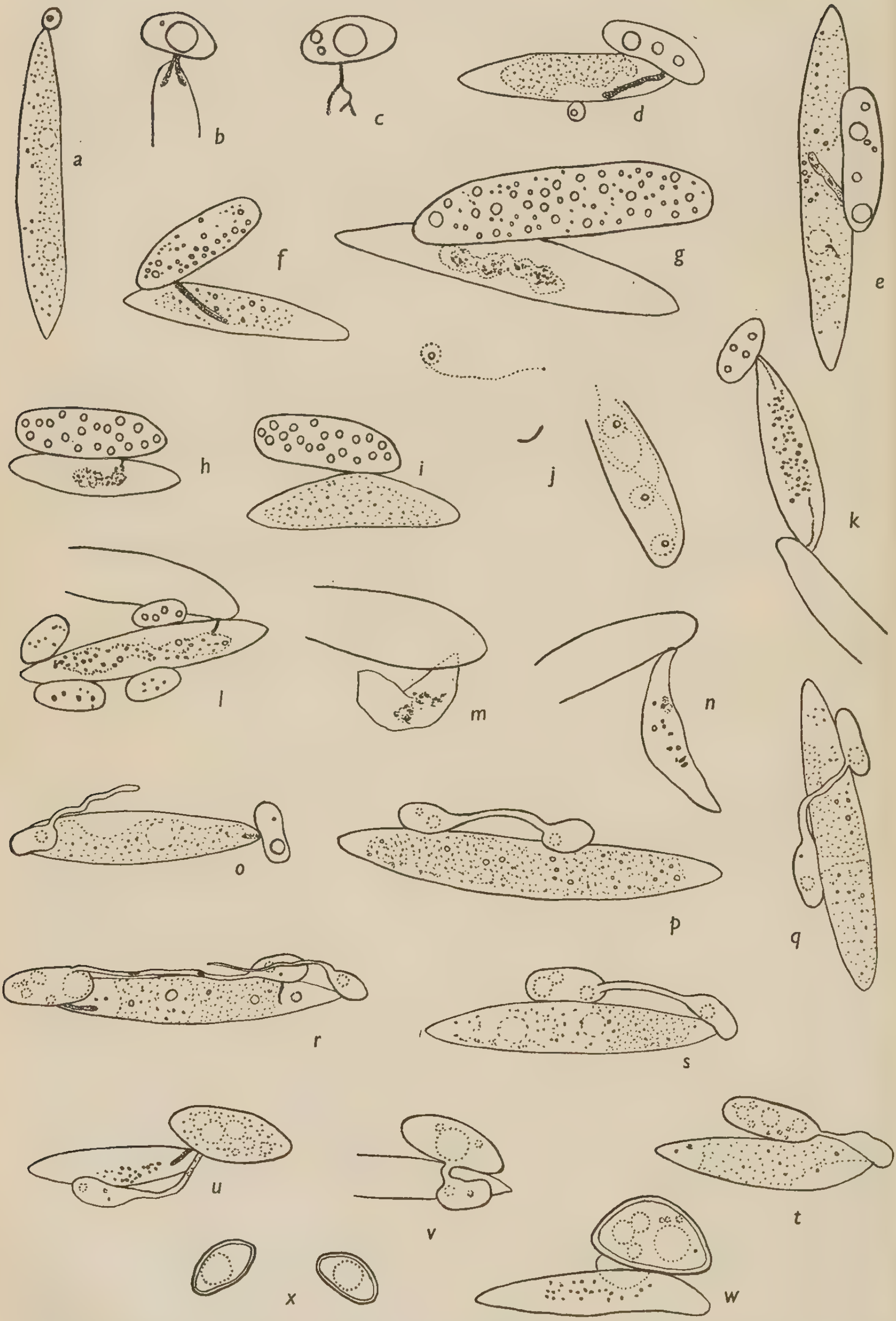
This fungus is parasitic on *Ankistrodesmus* sp., in Blelham Tarn, Windermere, Esthwaite Water, Crummock Water, Wastwater and Ullswater (Table 4). It has also been found on this alga in single collections from High Borrons Reservoir, near Windermere Town, Westmorland, and

St Johns Loch, Inverness-shire, Scotland (coll. H. C. Gilson). It has less frequently been observed on *Elakatothrix gelatinosa* Wille in Ennerdale and Windermere. Recent observations made by Dr J. W. G. Lund on *Ankistrodesmus* in the plankton of lakes in the Lake District suggest that two forms may be involved agreeing with the description of *Quadrigula chodati* (Tanner-Fullman) Smith and *Q. lacustris* (Chodat) Smith. There is disagreement among algologists whether these should be placed in *Quadrigula* or *Ankistrodesmus* and whether they are distinct species. If they are not distinct and placed in the latter genus, they may be placed in *Ankistrodesmus gelifactum* (Chodat) Bourrelly. Since, in the records to date, I have made no distinction concerning these forms for the present I list the alga as *Ankistrodesmus* sp.

The zoospore passes through the mucilage envelope of the alga and settles on a cell (Text-fig. 9*a*; Pl. 5, fig. 5). It enlarges into a sporangium which in the largest specimens is broadly cylindrical or cigar-shaped, 3–6 μ high and 8–26 μ long (Text-fig. 9*g*, *h*); while smaller sporangia vary from oblong to oval, 3–4 μ high and 4–5·5 μ long. The sporangium usually occurs with its long axis parallel to the length of the algal cell. If, however, a zoospore settles on the apex of a host cell then the sporangium may develop at right angles to the long axis of alga (Text-fig. 9*k*, *n*). The point of attachment of the sporangium to the alga is not centrally situated, thus it seems probable that the zoospore during its growth extends laterally more in one direction than the other. In small specimens this may be impossible to detect. The protoplasmic changes leading to the formation of about 4–40 globules, each indicating the position of a zoospore, are similar to those described for the majority of chytrids. Dehiscence occurs at the end farthest away from the point of attachment to the alga. This end is also more broadly rounded (Pl. 5, fig. 6 (*d*)) than the other, and in large sporangia the end which will dehisce can be predicted. After the detachment of an arched operculum the fully formed zoospores emerge rapidly. The zoospore is spherical (2 μ in diameter, flagellum 11 μ long) with a single latero-basal globule and greyish protoplasm containing a few minute granules. The sporangium does not collapse after dehiscence. Owing to the dense nature of the host content the rhizoidal system is very difficult to observe. Where visible, it takes the form of an unbranched or little branched (Text-fig. 9*b*–*f*) fairly thick rhizoid. During the development of the sporangium the host content contracts, changes from green to yellowish brown and finally only red globules remain, the cell wall itself may become shrivelled.

Table 4. *Occurrence of* Zygorhizidium parallelosede *on* Ankistrodesmus *sp. from the lakes sampled at weekly intervals*

Lake	1948	1949	1950	1951	1952
Blelham Tarn	24 May–4 June	5 Apr., 2 Aug.	No record	2 July	10–30 June
Esthwaite Water	9–15 Mar.	25 July	No record	4 June–2 July	2 June
Windermere north basin	24 May–21 June	31 May–8 June, 26 Sept.–3 Oct.	12 June	No record	3 June
Windermere south basin	25 May–22 June	9–21 June	12 Mar., 5–12 June	2 July	No record



Text-fig. 9. *Zygorhizidium parallelosede* sp.nov. *a*, zoospore. *b–g*, immature sporangia. *h, i*, mature sporangia. *j*, sporangium with zoospores and operculum. *k–n*, empty sporangia. *o*, male thallus with conjugation tube and (?) female thallus. *p, q*, early stages in contact of male and female. *r–v*, immature resting spores. *x, w*, mature resting spores with smooth thick wall. *x*, × 1100; others, × 1530.

The resting spore is formed after the conjugation of two thalli, more or less equal in size both of which have settled on the algal wall (Text-fig. 9*p*, *q*). The thalli are connected by a conjugation tube 0+–16 μ long which varies in length according to the distance apart of the thalli. The male is oval to elongate oval ($2 \times 3{\cdot}5$–$2 \times 6\,\mu$), and although a rhizoid is very rarely visible it is probable that all specimens possess it. It seems that the male cell does enlarge from the original zoospore size. Content remains can be seen in the male and the conjugation tube even when the female thallus is quite large and contact between the two thalli must have long since taken place. It is possible, although there is no definite evidence that the male may help to provide nourishment for the female. The resting spore is morphologically similar to the sporangium and its rhizoidal system, but it shows a slightly smaller range of size, 5·5–17 μ long and 3–6 μ high. The wall thickens, remains smooth, and although at this stage most specimens contain several globules, two spores were found in the debris of a sample which contained but a single globule (Text-fig. 9*x*). This may in fact represent the mature condition. The empty male remains connected to the mature resting spore.

Among the operculate chytrids sexually formed resting spores have been recorded for certain only in *Chytridium sexuale* Koch (1951), *Zygorhizidium willei* Löwenthal, *Z. verrucosum* Geitler, *Z. melosirae* Canter, *Z. parvum* Canter and *Z. planktonicum* Canter. Although the species of *Zygorhizidium* differ among themselves in the method of development of the sporangium and type of rhizoidal system, they all possess resting spores formed after fusion of a small male with a larger female thallus via a conjugation tube. Both the thalli are situated on the wall of the alga and the conjugation tube varies according to their distance apart. The fungus here described has a similarly formed resting spore but the fusing gametes seem to be isogamous rather than heterogamous. However, I do not consider this of sufficient importance to warrant the erection of a new genus, and include the fungus here described in *Zygorhizidium* and the name *Z. parallelosede* is proposed.

RECORDS OF PLANKTON PARASITES FROM SWEDEN

Preserved plankton samples sent to me by Drs G. Lohammar and A. Lundh of Sweden contained many fungi. Those I am able to name are listed below:

Alga	Lake	Date of collection	Fungus
Asterionella sp.	Hosjön	15, 22 Aug., 3, 18, 25 Oct. 1949	*Zygorhizidium planktonicum* Canter
Ceratium hirundinella O.F.M. and *Peridinium* sp.	Munkloosjon	8 Sept. 1951	*Amphicypellus elegans* Ingold
Eudorina elegans Ehrenb.	Ullvifjarden	15, 29 Aug. 1949	*Endocoenobium eudorinae* Ingold
Rhizosolenia sp.	Åsgarn	13 Nov. 1949	*Rhizophidium planktonicum* Canter
Sphaerocystis sp.	Hosjön *Gyllebosjon	5, 26 Sept. 1949, 9 May 1949	*Zygorhizidium parvum* Canter
Synedra sp.	Ullvifjarden	17 Nov. 1949	*Z. planktonicum* Canter

* From Dr A. Lundh's collection, the remainder from that of Dr G. Lohammar.

My thanks are due to Drs B. Fott, Charles University, Czechoslovakia, E. M. Lind, Makerere College, Uganda, G. Lohammar, Uppsala and A. Lundh-Almestrand, Lund, Sweden, and V. Tonolli, Pallanza, Italy, for kindly sending me plankton samples. Also I am indebted to Mr G. Thompson of the Freshwater Biological Association for organizing the Lake District sampling and to members of the Laboratory Staff who collected the samples. Dr J. W. G. Lund I thank for naming the algae and for the German translations, Prof. C. T. Ingold for reading the manuscript and the Central Research Fund of the University of London for a grant enabling me to purchase apparatus used in this investigation.

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EXPLANATION OF PLATES 3–5

Plate 3

Fig. 1. *Rhizophidium uniguttulum* sp.nov.; part of a *Gemellicystis* colony with developing sporangia containing a single large globule. (× 750.)

Fig. 2. *R. uniguttulum*; two sporangia in later stages of development. The numerous dots are recently liberated zoospores (out of focus) still within the algal mucilage. (× 750.)

Fig. 3. A chytrid which occurs on *Coelosphaerium* in the Lake District. The rhizoidal system is polyphagous; dead cells are grey in the photograph (cf. the living black ones). (× 1125.)

Fig. 4. *Rhizophidium difficile* sp.nov.; a cell of *Staurastrum jaculiferum* after dehiscence of the sporangium; dense network of rhizoids is seen at (*x*) (× 770.)

Plate 4

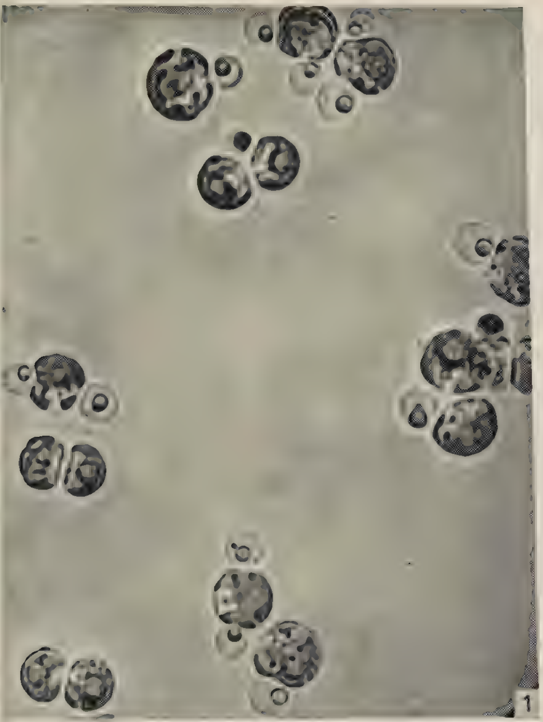
Rhizosiphon akinetum sp.nov., on *Anabaena affinis* Lemm. var. *intermedia* Griffiths. (× 1600)

Fig. 1. Akinete with empty encysted zoospore (*z*).

Fig. 2. Inside the akinete are three empty sac-like prosporangia (*p*); one sporangium is distinguishable at (*s*) and its empty zoospore case at (*z*).

Fig. 3. Mature sporangium with hairy wall and apical papilla.

Fig. 4. Empty sporangium with its persistent zoospore case (*z*).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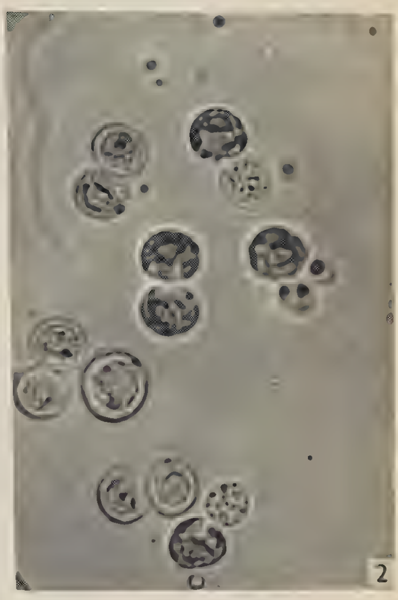
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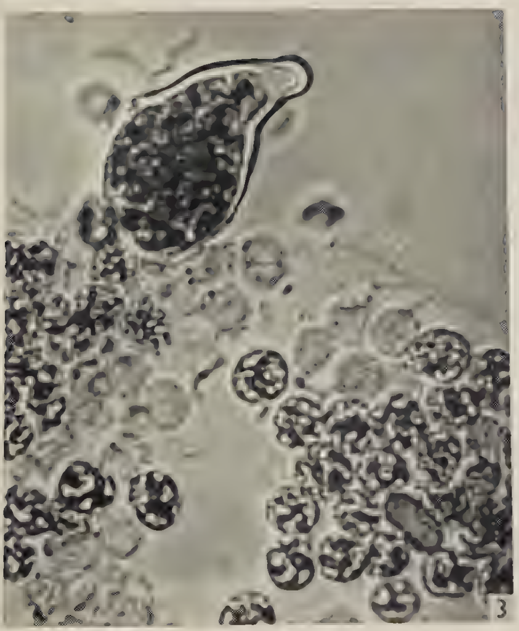
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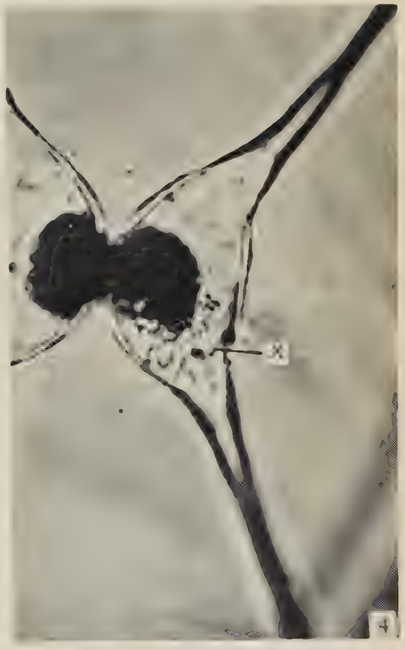
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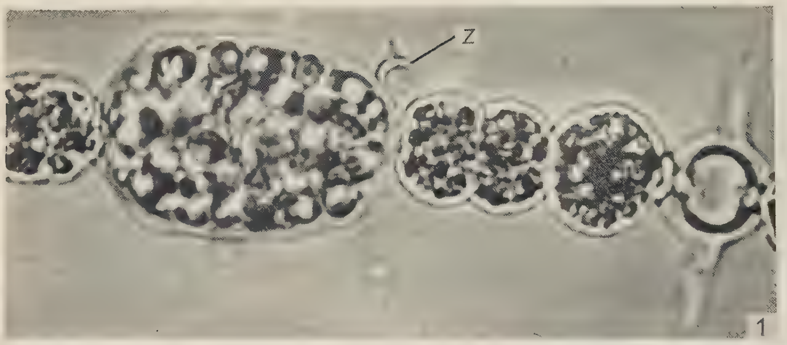
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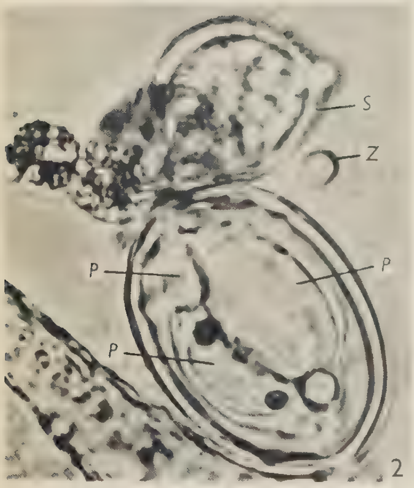
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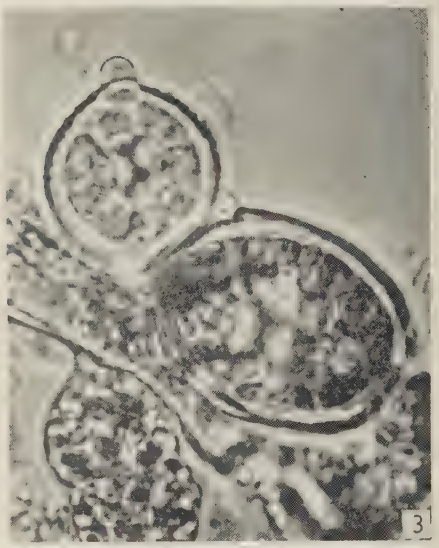
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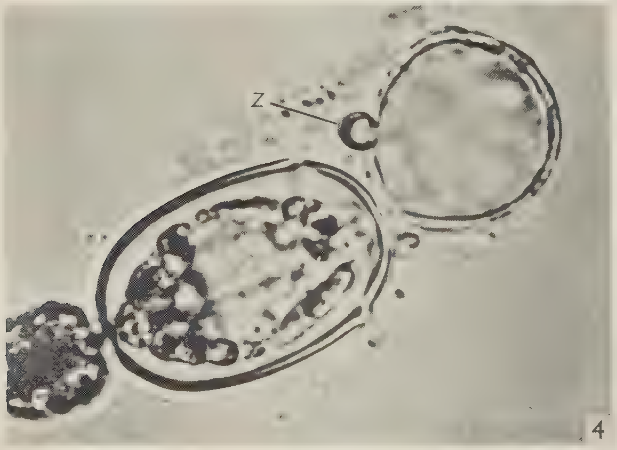
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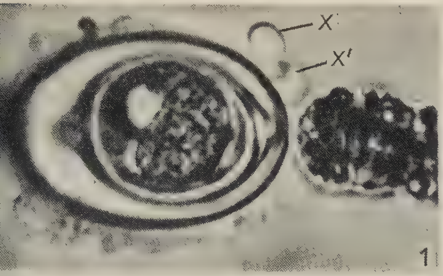

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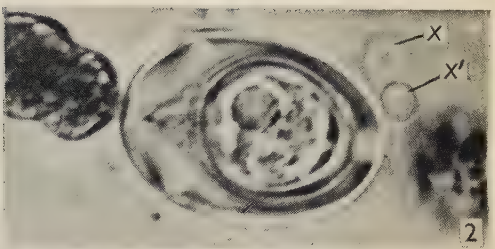

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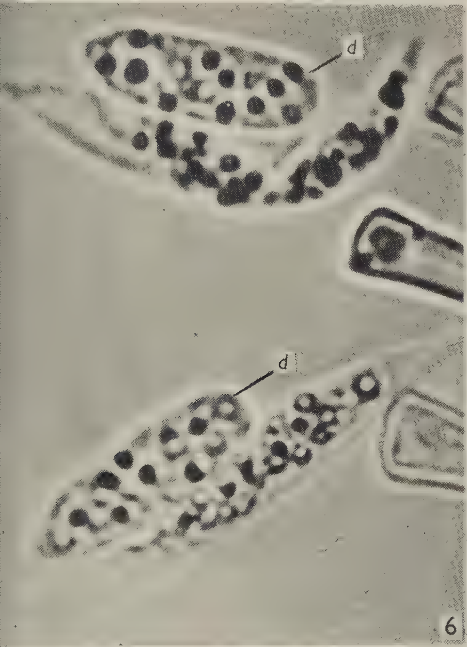

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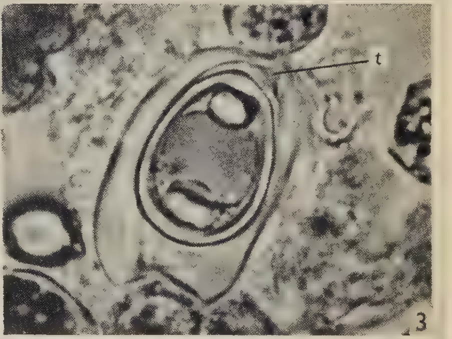

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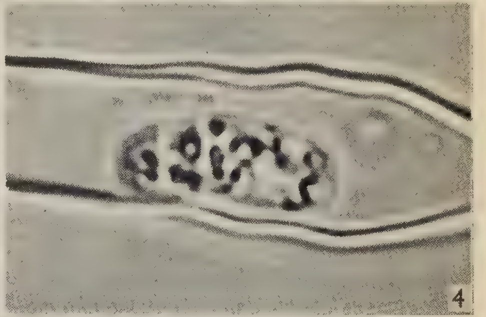
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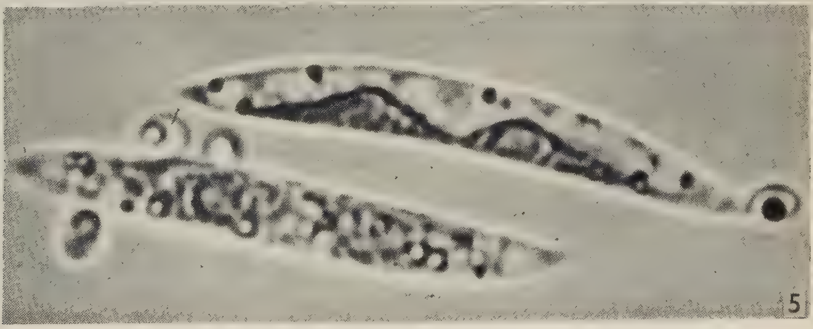
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Plate 5

Figs. 1, 2. *Rhizosiphon akinetum* sp.nov.; resting spore showing the two isogamous gametes which are associated with it. In fig. 1 the uppermost gamete is in focus (*x*), the lowermost is out of focus (*x'*); in fig. 2 this is reversed. (× 1600.)

Fig. 3. *R. akinetum* sp.nov.; mature resting spore. (*t*) triangle of refractive material. (× 1600.)

Fig. 4. *Rhizophidiam oblongum* sp.nov.; sporangium inside the envelope of a *Dinobryon* cell. The protoplast of the alga has passed out of the envelope due to pressure from the coverslip. (× 2770.)

Figs. 5, 6. *Zygorhizidium parallelosede* sp.nov. on *Ankistrodesmus*: fig. 5, zoospores; fig. 6, mature sporangia; (*d*) marks broader end where dehiscence will take place. (× 2770.)

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SOMMERSTORFFIA SPINOSA AND *ZOOPHAGUS INSIDIANS* PREDACIOUS ON ROTIFERS, AND *ROZELLOPSIS INFLATA* THE ENDOPARASITE OF *ZOOPHAGUS*

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(With 8 Text-figures)

Sommerstorffia spinosa Arnaudow is reported from Britain for the first time. The sparingly branched thallus captured rotifers by crozier-shaped mucilage tips, only loricate forms being captured. Asexual reproduction was by zoosporangia of the *Aphanomyces* type, filamentous with a single row of zoospores encysting immediately on emergence. An oogonium containing seven eggs, and a branched antheridium were seen in one infected rotifer.

Zoophagus insidians Sommerstorff captures rotifers by specialized peg-like lateral branches, but no mucilage could be demonstrated. *Zoophagus* also selects loricate rotifers. Asexual reproduction was by means of zoosporangia of the Aphragmium (*Pythium*) type. No sexual organs were seen. The fungus was brought into culture on oatmeal agar for the first time, with difficulty. In culture it behaved like a *Pythium* of the Aphragmium type, no specialized capturing organs being formed. It still retained some ability to capture loricate rotifers selectively.

Rozellopsis inflata Karling is described as parasitizing *Zoophagus insidians* occurring both in nature and in culture. The zoosporangia of *Rozellopsis inflata* were formed in swellings of the host hypha, and the laterally biflagellate zoospores were much smaller than those of the host. Infection of the host, development of the sporangia and emergence of the zoospores were all seen, and showed great resemblance to the stages in *Rozellopsis waterhousei*. *Pythium intermedium*, and some unidentified species of *Pythium* were successfully infected, but not *Phytophthora megasperma*.

Sommerstorffia spinosa Arnaudow

Sommerstorffia spinosa appears to be a comparatively rare fungus, although Karling (1952) reports it from soil in several places in the United States. I have found it in only one collection of *Cladophora* taken from the water-garden at Kew and there appears to be no previous record of the fungus from Britain. The fungus made its appearance only after the *Cladophora* had been kept in the laboratory for a month, and a close study was made of it before it died out.

A typical specimen consists of a basal portion, by which it is attached to the alga, and from which arise 5–7 isodiametric branches, $6\,\mu$ wide × 60–$70\,\mu$ long, modified as capturing organs (Fig. 1 *b*). Sometimes a detached plant was seen in which growth was both more branched and more extensive (Fig. 1 *a*). At the tip of each capturing organ was a highly refractive pointed part, and attached to this was a thin crozier of mucilage

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1 μ wide × 15 μ long (Fig. 1 *c*). These mucilage tips were often obscured by debris or by the captured rotifer, but clean specimens could be seen quite easily without staining, and it is on these mucilage tips that the animals appear to be captured.

In the material under observation only the loricate rotifers *Distyla* and *Monostyla* were captured, while the soft-bodied forms *Rotifer* and *Philodina* were able to crawl over the fungus without being affected. Karling (1952) reports similar observations, but makes no mention of the lorica. He does, however, report that the protozoan *Entosiphon* was captured, and it is interesting that this organism possesses a 'pharynx'. With *Zoophagus insidians*, which shows a similar selectivity of rotifers, I have found that *Philodina* was captured on three occasions by actually biting the capturing organs. The capture of the loricate forms appears to be by adhesion of the mucilage tip to the lorica, usually on the ventral surface, as the forms captured browse along the filaments of the alga on which the fungus grows. As soon as the rotifer is captured it struggles to break itself free by trying to bite itself away from the capturing organ. In the struggle the crozier of mucilage is evidently forced between the trophi and becomes more firmly attached. One specimen was seen with a portion of the mucilage tip just passing in through the trophi. As soon as the refractive tip begins to penetrate the trophi the refractive portion breaks up into small granules which begin to vibrate, and this vibration passes backwards through the

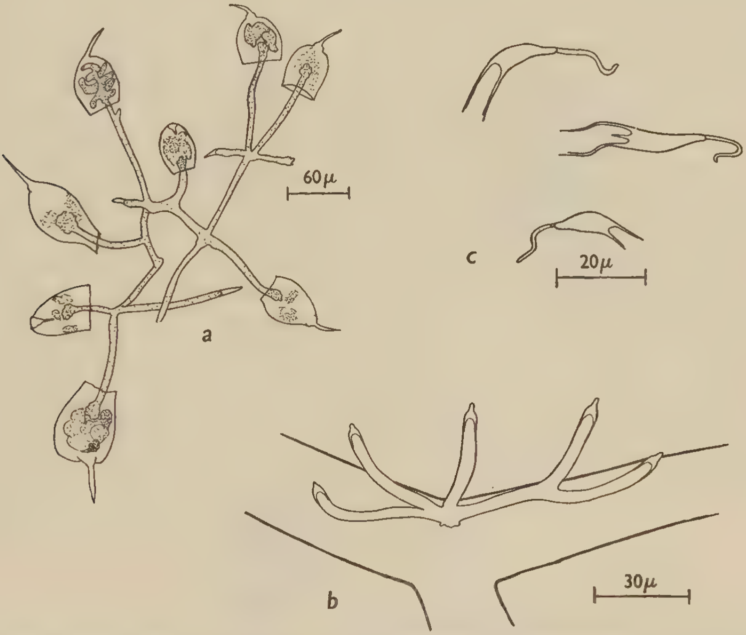

Fig. 1. *Sommerstorffia spinosa* Arnaudow: (*a*) detached fungus bearing several captured rotifers; (*b*) typical individual growing on *Cladophora*; (*c*) refractive tips of the capturing organs showing the croziers of mucilage.

capturing organ. A similar reaction is to be seen in *Zoophagus insidians*, which however has no demonstrable mucilage tip. Karling (1952) describes the rotifers as being caught by 'chewing' the tip of the capturing organ, but there is no doubt that in the material from Kew the rotifers were first caught by adhesion to the lorica.

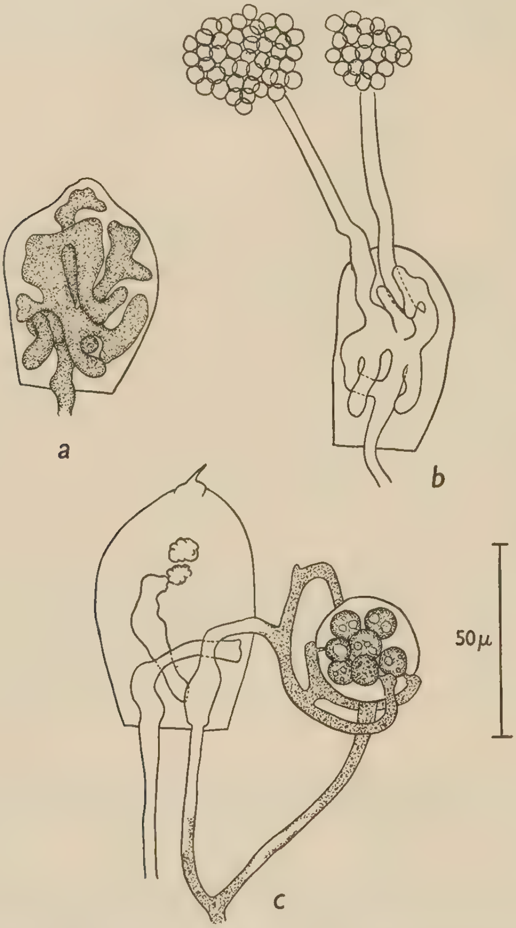

Fig. 2. *Sommerstorffia spinosa* Arnaudow: (*a*) thallus inside the parasitized rotifer; (*b*) zoosporangia bearing empty cysts; (*c*) oogonium and antheridium.

After about 12 hr. a twisted non-septate thallus is formed within the rotifer (Fig. 2*a*), and this eventually gives rise to the asexual reproductive organs. One to two zoosporangia usually arise from the rear of the animal. Each consists of iso-diametric filaments 5–6μ wide, projecting 90–100μ out from the animal. The zoospores are formed in a single row, and encyst at the mouth of the sporangium immediately on emergence, each cyst measuring 5–6μ in diameter (Fig. 2*b*). In its mode of asexual reproduction

Sommerstorffia very closely resembles species of *Aphanomyces*, although Karling reports cases where the zoospores were not in a single row.

Sexual organs of the fungus were seen on one specimen of *Monostyla* caught on a capturing organ (Fig. 2*c*). The oogonium arose from a branch near the base of the capturing organ on which the animal was caught; it measured 30μ in diameter, had a smooth wall and contained seven eggs, each 8μ in diameter and containing conspicuous oil globules. The antheridium arose from the internal thallus of the rotifer, evidently after all the zoospores had been liberated; it emerged from the side of the infected animal and had four branches 6μ wide, closely applied to the oogonial wall. Fertilization of the eggs was not seen. Arnaudow (1923) reported apandrous oogonia in his material, each oogonium containing one oospore. Neither Sparrow (1929) nor Karling (private communication) have seen the sexual organs, although the latter has observed material from several different sources. The material from Kew thus differs from both Arnaudow's specimens and from the genus *Aphanomyces* in having several eggs to each oogonium. However, only one set of sexual organs was seen in the Kew material, and although they were quite clearly part of the general thallus of *Sommerstorffia* (since typical capturing organs arose from the same basal holdfast) they might easily have been abnormal ones.

From its filamentous sporangia with the zoospores in a single row, and the way that the latter encyst at the mouth of the sporangium immediately on emergence, *Sommerstorffia spinosa* comes very near to *Aphanomyces*. Karling (1952) reports that in his Alaskan material some of the zoosporangia were swollen with more than one row of zoospores, and so were closer in appearance to *Achlya*. It is just possible that there may be more than one fungus involved, but until more is known about it and until there are more observations of the sexual organs, it seems better to retain all the collections in *Sommerstorffia spinosa*.

Zoophagus insidians Sommerstorff

Although reports of *Zoophagus insidians* have been infrequent, it is evidently more widespread than *Sommerstorffia*. The material on which these studies were made was taken from seven collections of algae; from Studland, Dorset; from the water-garden at Kew; and from five Scottish lochs. In all cases the fungus appeared after the algae had been kept in the laboratory for a month. Reports concerning the fungus are confusing, and sometimes conflicting, so an intensive study was made of the fungus. Using oatmeal agar it was brought into culture for the first time and its behaviour in culture has proved of particular interest.

Field material

The mycelium of field specimens consists of slender, sparingly branched hyphae, 4–6μ wide, bearing numerous unbranched peg-like capturing organs 20μ long × 3μ wide, arising at right angles to the main hyphae with which they are continuous (Fig. 3*a*). There is no specialized attachment region as in *S. spinosa*. The fungus ramifies between and upon algae (Fig. 4*c*), or creeps over the bottom of the culture dish. In such a position it is ideally suited to capture rotifers browsing along the algal filaments or along the bottom of the dish (Fig. 3*b*). As with *Sommerstorffia* only loricate forms are captured, usually on the ventral surface. Fast-moving forms such as *Anuraea* are too powerful to be captured, but the browsing forms, *Distyla*, *Monostyla*, *Diplois* and *Diplaxis*, are almost eliminated from the culture dish. The soft-bodied forms, *Rotifer* and *Philodina*, are able to crawl over the peg-like capturing organs without being affected. Three specimens of *Philodina* have been seen captured, but in each case the capturing organ was swallowed by the animal before infection could take place.

Although the capturing organs have highly refractive tips, no mucilage could be detected on them by ordinary means (Ruthenium red, Alcian blue and indian ink). On three occasions where specimens of *Distyla* were seen partially to escape, the lorica was attached to the tip of the capturing organ by a thin thread of mucilage less than 0·5μ wide. Attempts to stimulate the production of mucilage by touching the tips of the capturing organs with fine needles or with glass threads were unsuccessful. It seems possible that the production of mucilage is initiated by contact with the body of the rotifer, which then becomes firmly attached. Normally the body of the animal will obscure the tip, so that mucilage, if present, will not be visible. Contact of the rotifer with the tip produces an immediate reaction; the refractive portion breaks up into granules which begin to vibrate, and this vibration spreads quickly throughout the main hypha. Penetration of the rotifer usually takes place through the trophi, and the capturing organ eventually swells out inside the animal to form a twisted, non-septate thallus (Fig. 4*a*, *b* and *e*).

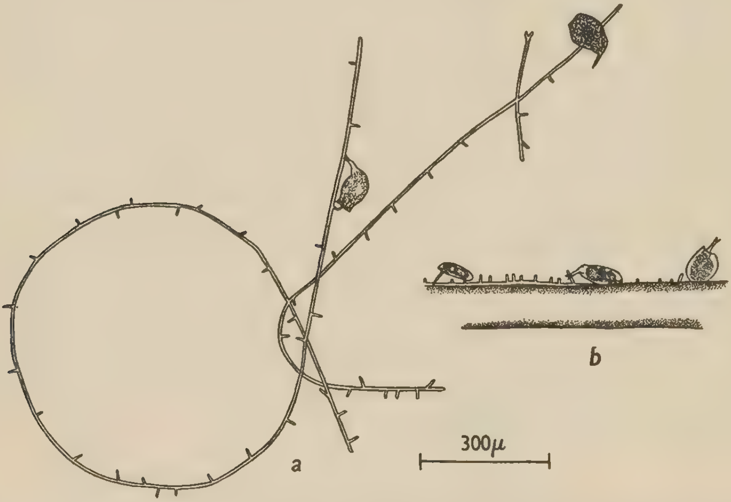

Fig. 3. *Zoophagus insidians* Sommerstorff: (*a*) general habit of the field material; (*b*) hypha growing along *Cladophora* showing how the capturing organs are orientated to catch rotifers.

Zoosporangia were rarely seen in field material, and occurred only in one collection from Loch Dunmore, Perthshire. Each zoosporangium consists of an undifferentiated portion of the thallus within the rotifer, with an

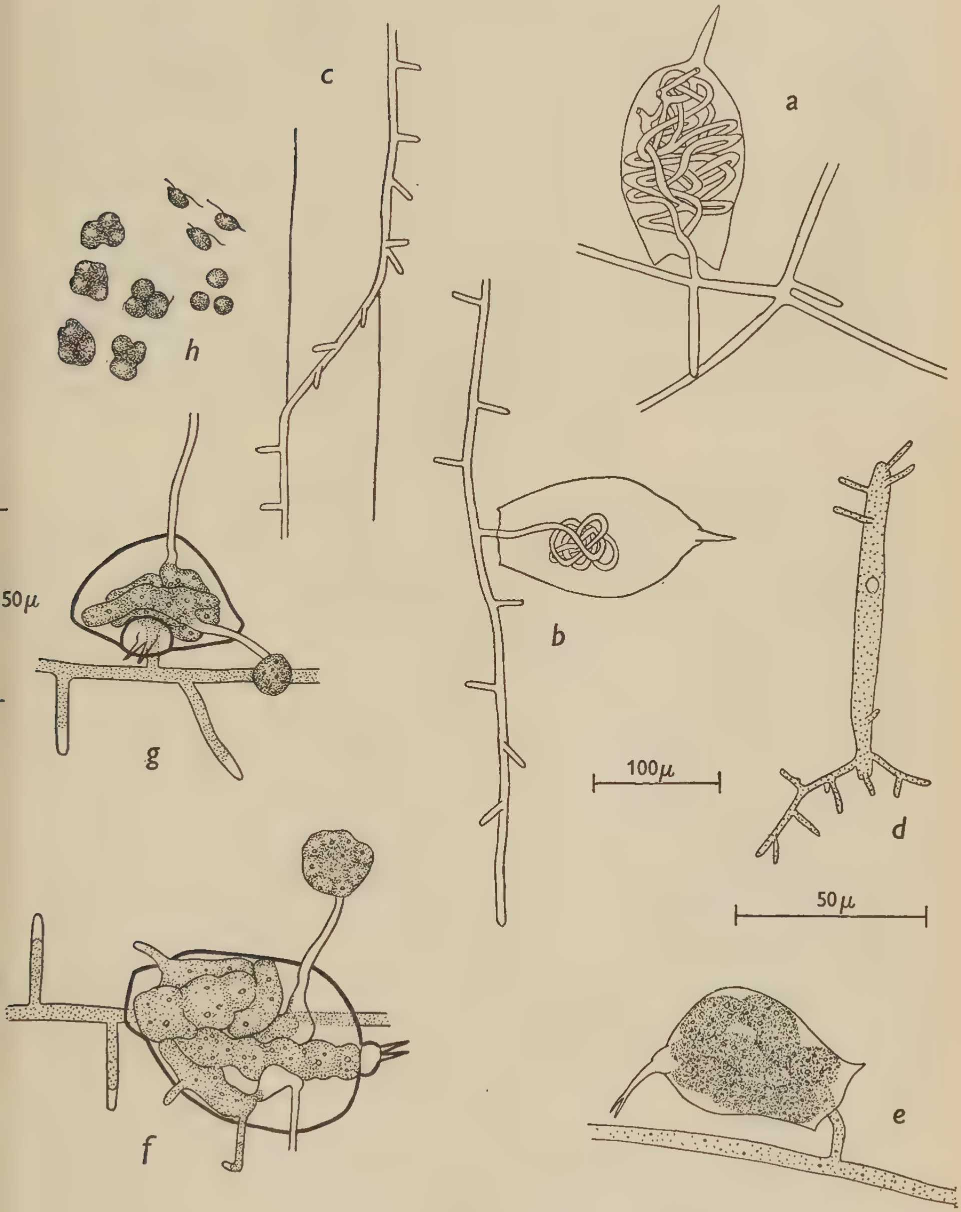

Fig. 4. Field material of *Zoophagus insidians* Sommerstorff: (*a*, *b*) hyphae bearing captured rotifers; (*c*) habit of hypha growing on *Cladophora*; (*d*) germinating gemma; (*e*) formation of the thallus inside the infected rotifer; (*f*, *h*) formation of zoosporangia and zoospores. (*d*–*h*) on different scale to (*a*–*c*).

evacuation tube 2–3 μ wide projecting 25–30 μ out from the wall of the animal. There are usually 1–3 zoosporangia to each parasitized rotifer, with no wall dividing them from the main thallus. Zoospores are discharged into a vesicle 10–20 μ in diameter, with 3–15 zoospores in each vesicle. The zoospores are pyriform, 5 × 3 μ, with two laterally attached flagella, the anterior 2 μ and the posterior 4 μ long (Fig. 4*f*–*h*). Repeated encystment may occur. In its method of zoospore formation *Zoophagus insidians* thus resembles a species of *Pythium* belonging to the Aphragmium section.

Fusiform gemmae, 80–100 × 8–10 μ, have been found only in the Kew material, and then usually detached. On one occasion a gemma was seen being budded off from the end of a long hypha, and this is probably the normal method of production. The gemmae may be septate or non-septate, germinating at either end to produce typical capturing organs (Fig. 4*d*). In all respects the gemmae closely resemble those described by Arnaudow.

Culture on oatmeal agar

After thirty-eight unsuccessful attempts I have been able to culture it on oatmeal agar. There appears to be no previous record of *Zoophagus insidians* being cultured on solid media. Separate hyphae were dissected out, or filaments of alga or leaflets of *Myriophyllum* bearing the fungus were used as inoculum and washed several times in sterile water before being placed on the surface of the agar. Either the fungus would not grow, or else it grew so slowly as to be overgrown with bacteria, and it was not until a plate accidentally poured at 50° C. was used that success was attained. Evidently the increased amount of surface moisture under such conditions was sufficient to tide the fungus over the critical early stages of growth. Fifteen cultures were made in this way.

In culture the fungus underwent such a marked change that it might have been doubted whether the culture material was *Zoophagus insidians*. All fifteen cultures, however, produced exactly the same strain of fungus, and, as in two cultures growth was watched from inoculation with a single hypha to quite extensive mycelial development, there can be little doubt that the fungus in culture was *Z. insidians*. Initial growth was slow, and by the end of 24 hr. the only change that had taken place was the elongation and irregular growth of the peg-like capturing organs, and slight extension of the main hypha. At the end of 3 days, growth was much more vigorous, the hyphae radiating about 1 cm. from the point of inoculation. Growth was irregular, with frequent branching, and sometimes with groups of 3 or 4 hyphae running parallel through the substrate, and at the end of a week the culture had developed into a close mat of fluffy aerial hyphae. Once the initial culture was made it was quite easy to subculture and subsequent growth was rapid.

When transferred to water the culture material produced abundant zoosporangia of the Aphragmium type, with evacuation tubes 100 μ long × 4 μ wide, and vesicles containing 20–50 zoospores, each zoospore measuring 10 × 5 μ (Fig. 5*b*). Although long straight hyphae are occasionally produced, the laterals are often swollen in outline, and quite unlike

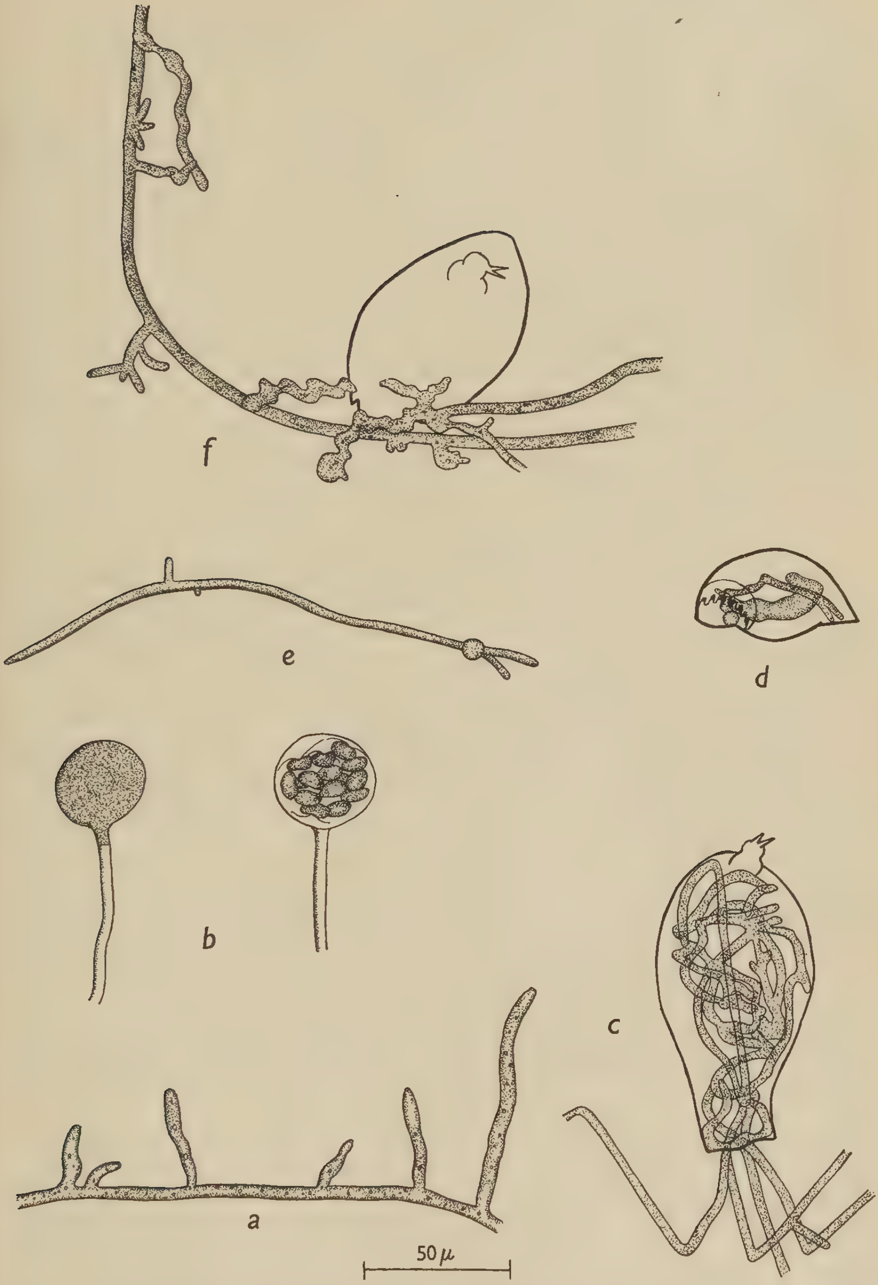

Fig. 5. *Zoophagus insidians* Sommerstorff: (*a–e*) culture material; (*a*) hypha showing the irregular growth of the laterals; (*b*) zoospore formation; (*c*) parasitized rotifer showing the mouth orientated downwards to the infecting hyphae; (*d*) zoospores germinating inside a rotifer; (*e*) germinated zoospore from an old culture showing a more regular type of growth; (*f*) field material showing the irregular laterals that sometimes occur.

the peg-like capturing organs of the field material (Fig. 5*a*). No refractive tips have yet been observed, and frequently the laterals grow out to form long branches. Field material, however, occasionally shows similar irregularities in its capturing organs (Fig. 5*f*).

Because of the morphological differences shown by the culture material, rotifers were introduced in order to investigate its predacious ability. About a dozen specimens of a species of *Distyla* were pipetted into a dish of water containing culture material. A few hours later all the rotifers were found to be clustered on the culture material, and by the following day they seemed to be breeding quite freely among the hyphae. Rotifers have also been seen to breed freely in cultures of several species of *Pythium* similarly treated, but not on cultures of *Saprolegnia* or *Achlya*, nor on plain oatmeal agar. In the *Zoophagus* culture it soon became evident that rotifers were being parasitized (Fig. 5*c*), and in many cultures all the rotifers were destroyed by the end of the third week, whereas with the *Pythium* so few rotifers were found 'parasitized' at the end of that period that it seemed probable that these animals were already dead before being infected. When mixed cultures of *Distyla* and *Rotifer* were introduced into the *Zoophagus* culture all the *Distyla* were eliminated, while the *Rotifer* remained breeding. This agrees with the selective ability of the field material. In the *Pythium* culture both species continued to breed and there was no real sign of parasitism. The orientation of the parasitized *Distyla* suggested that the animals were being actively captured, and one rotifer was observed struggling to escape from a short lateral hypha. However, the predacious ability of the cultured fungus is much less than that of the field material, where rotifers quickly become strung along a single hypha. Such a decrease in parasitism is not unusual in the fungi. Occasionally rotifers have been seen which have swallowed zoospores of the fungus, and these zoospores have germinated to produce hyphae projecting through the mouths of the animals.

Attempts to induce the culture material to revert to the typical field form, with the peg-like capturing organs, have so far been unsuccessful. Regenerating hyphae show a marked resemblance to the field material, with short laterals, but there are no refractive tips and growth is very limited. However, a rotifer was seen captured on a lateral on one occasion. It is possible that the problem is a nutritional one.

Sexual organs were not seen in any of the material, and the only record so far is that by Arnaudow (1925) who describes the fungus as heterothallic.

Systematic position

From the foregoing description of zoospore formation, both in field and culture material, it is evident that *Zoophagus insidians* is closely allied to species of *Pythium* belonging to the Aphragmium section, and in this respect it agrees with the descriptions given by Arnaudow (1921) and Sparrow (1929). The fungus described by Gicklhorn (1922) differed in that the zoosporangium was globular or saccate, and the zoospores were formed inside the sporangium before discharge, thus resembling the condition in *Phytophthora*. Gemmae have been described in both the accounts by Arnaudow (1921, 1925), and those reported in the present studies agree closely with them. *Zoophagus tentaclum*, which differs in that its capturing organs bear slender tentacles, produces similar gemmae (Karling, 1936). Arnaudow's German collection of *Z. insidians*, the present Kew material, and Karling's *Z. tentaclum* did not produce zoospores, so that it is possible that they might be conidial Phycomycetes. Arnaudow's Bulgarian material, however, produced both zoospores as well as gemmae, so that it is possible that the mode of asexual reproduction is bound up with physiological conditions. The discrepancies between the various descriptions, and in particular between those of the zoospore formation by Gicklhorn and other workers, suggest that the binomial *Z. insidians* covers several fungi which agree in the method of capturing rotifers, but not in their non-sexual stages. The evidence, however, is in favour of them all being members of the Pythiaceae, despite Valkanov's attempt (1932) to place *Synchaetophagus*, *Hydatinophagus*, *Sommerstorffia* and *Zoophagus* together as a special group in the Saprolegniaceae, based solely on their ability to parasitize rotifers.

A culture of *Z. insidians* and slides of the field material will be deposited at the Commonwealth Mycological Institute, Kew.

Rozellopsis inflata (Butler) Karling (*Pleolpidium inflatum* Butler)

When culture material of *Zoophagus insidians* was placed in water from Loch Dunmore, Perthshire, it was found that large terminal and intercalary swellings had developed on the hyphae after a few days. Close examination revealed that these swellings were the zoosporangia of the endoparasite *Rozellopsis inflata*. This fungus has been recorded only once before by Butler (1907), under the name of *Pleolpidium inflatum*, the host on that occasion being *Pythium intermedium*. Later it was found that some of the predacious field material of *Zoophagus* was also infected, possibly by the introduction of fresh weed from the loch.

The biflagellate zoospores of *Rozellopsis inflata* are hyaline, with two refractive granules, and are often elongate in the zoosporangium, but tend to become nearly spherical, 2–3 μ in diameter, when they emerge. They have two unequal laterally inserted flagella, of which the shorter (2 μ) points forward, and the longer (6–10 μ) backwards.

The zoospores were seen to swim with a very even motion, and during swimming the anterior flagellum underwent rapid spiral motions, while the posterior flagellum trailed passively behind. When the long flagellum touched the wall of a host hypha it became attached, and by its contraction the zoospore was drawn smoothly down to rest on the host wall. During this process the anterior flagellum apparently disappeared. On several occasions rows of zoospores were seen, each attached to the host wall by the long flagellum (Fig. 6*b*).

Normally the zoospore encysts and germinates on the wall of the host, and open communication is established between the zoospore and host cell. Refractive oil globules then begin to stream away from the point of infection, the protoplasm of the host in the immediate vicinity becoming dense in appearance. This dense appearance continues until eventually a considerable portion of the infected hypha becomes semi-opaque. The zoospore case remains attached to the host wall, and is not completely vacated until the opacity in the host protoplasm has spread considerably in extent (Fig. 6*a*). It may, however, be destroyed later, presumably by bacterial action. At no time is it possible to distinguish the protoplasm of

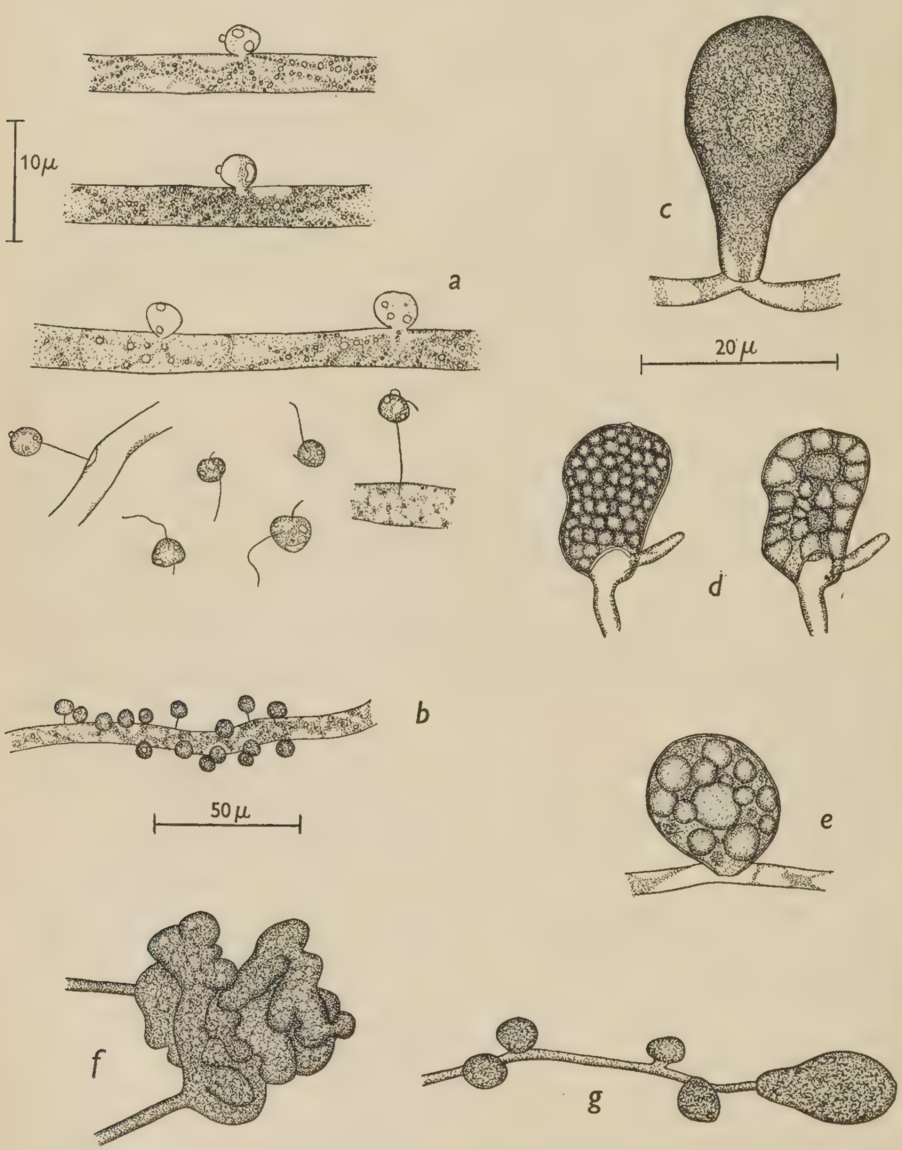

Fig. 6. *Rozellopsis inflata* Karling: (*a*, *b*) infection of hyphae of culture material of *Zoophagus insidians* by the zoospores of the parasite; (*c*–*e*) stages in the development of the swollen zoosporangia of *Rozellopsis inflata*; (*f*) abnormal zoosporangium; (*g*) terminal and intercalary zoosporangia. (*c*–*g*) all on the same scale.

the parasite from that of the host, and the plasmodium, if it exists, must be very finely diffused throughout the host protoplasm. In the Plasmodiophorales, on the other hand, the infecting organism enters as a single, clearly definable, naked mass of protoplasm and no zoospore case is left attached outside.

The zoosporangium begins as a swelling, either terminal or intercalary, in the host hypha, and as the swelling enlarges the opacity of the protoplasm increases. A central vacuole can sometimes be seen at this stage (Fig. 6*c*). Terminal sporangia are usually pyriform, 50–80μ wide × 90–120μ long, separated from the rest of the hypha by a thick wall, apparently formed by the host. Quite often there is also a subsporangial swelling of the hypha. 'Intercalary' sporangia are more frequent than terminal ones, the larger sporangia being pyriform, 50 × 90μ, and laterally displaced. Comparison with infected field material suggests that these sporangia may possibly be formed from short laterals of the host infected by the parasite. Smaller sporangia are often formed (Fig. 6*g*) and these are usually spherical and quite often strictly intercalary, with two dividing walls cutting them off from the rest of the host hypha. Occasionally highly irregular zoosporangia are formed, but these can produce zoospores in the normal way (Fig. 6*f*). After 24 hr. the protoplasm in the zoosporangium becomes coarsely reticulate in appearance, as if about to cleave into large zoospore initials. Evenly spaced oil droplets then begin to separate out, and these quickly coalesce into larger drops (Fig. 6*d*, *e*).

At this stage, one or more papillae may be formed, often so prominent as to appear almost hemispherical. Although no distinct wall for the zoosporangium of *Rozellopsis inflata* can be seen, plasmolysis clearly demonstrates that it possesses a delimiting membrane. The protoplasm may remain for several hours in the stage showing oil drops, but eventually it becomes clear (Fig. 7*c*), often quite suddenly, and all the oil drops disappear or occasionally one or two large ones may remain. After an hour the protoplasm again becomes reticulate, this time much more finely, and cleavage into zoospore initials takes place. By this time the exit papilla may have disappeared, leaving a very delicate membrane over the opening. A zoosporangium may contain 1000–1500 zoospores, very densely packed together (Fig. 7*a*). When they begin to move about they are necessarily restricted, until one of them bursts the membrane and they emerge one by one. As the sporangium empties, the characteristic swirling movement of the zoospores becomes evident (Fig. 7*b*) and they begin to move faster and faster until all of them have vacated the sporangium. One or two large oil drops may remain in the empty sporangium. A similar series of changes seems to take place in the maturation of the zoosporangium of *R. waterhousei* Karling (Waterhouse, 1940) and *R. septigena* Karling (Prowse, 1951), and the mode of liberation of the zoospores is almost identical.

In field material of *Zoophagus insidians* infected by *Rozellopsis inflata* only the capturing organs of *Zoophagus* appear to be converted into *Rozellopsis* zoosporangia, the shape of the zoosporangia being very characteristic, oval to pyriform (Figs. 8*a*–*f*). They are usually much smaller than the zoosporangia produced in culture material, measuring 50–60 × 20–25μ.

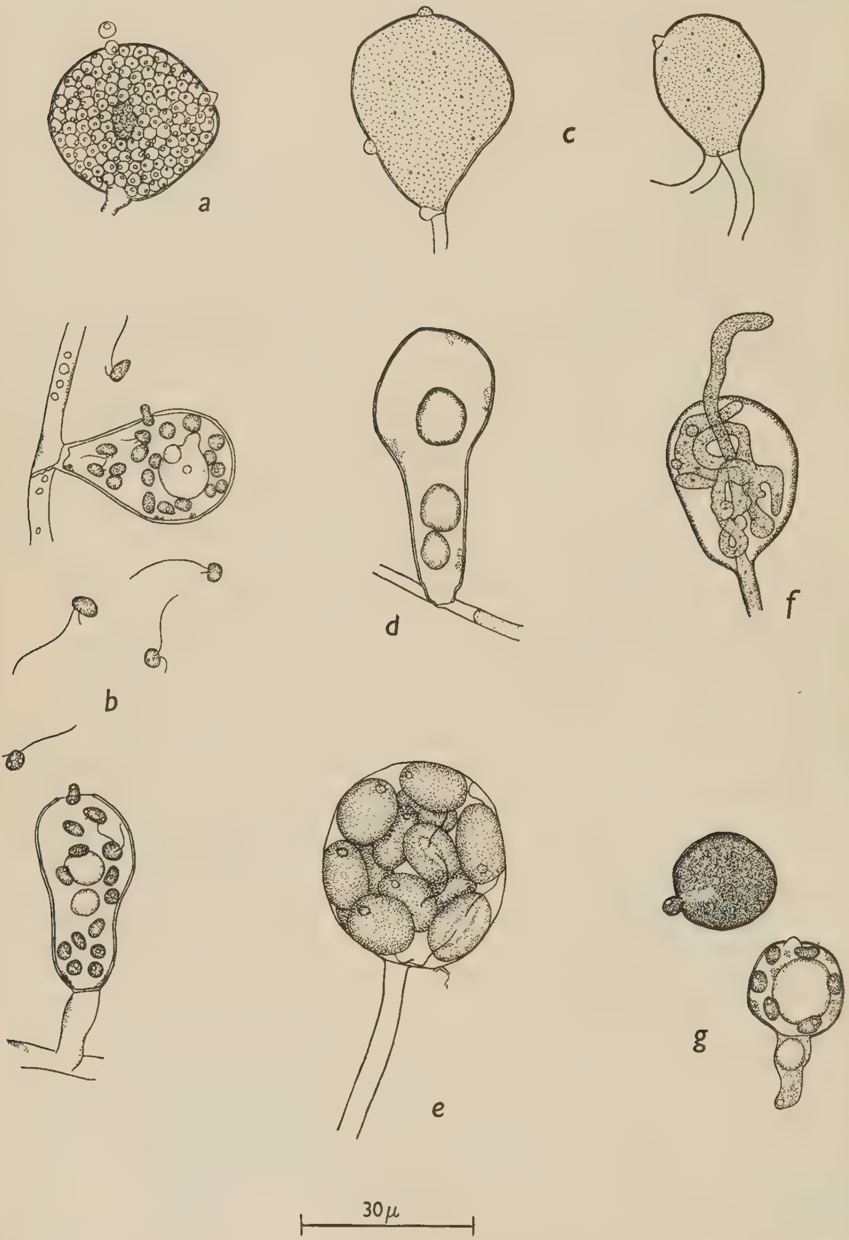

Fig. 7. *Rozellopsis inflata* Karling: (*a*, *b*) liberation of zoospores; (*c*) stage showing clear protoplasm in the sporangium just before cleavage into zoospore initials; (*d*) empty sporangium showing oil drops; (*e*) zoosporangium of the host *Zoophagus insidians* showing the much greater size of the zoospores; (*f*) hypha of the host *Zoophagus insidians* growing through an empty zoosporangium of *Rozellopsis inflata*; (*g*) encysted zoospores of *Zoophagus insidians* infected by *Rozellopsis inflata* and converted into the sporangia of the latter.

Once *R. inflata* had appeared on the culture material of *Zoophagus insidians*, it was possible to infect further cultures of the latter simply by introducing small pieces of heavily infected material, freely producing spores of the parasite, into a dish of water containing fresh culture material of the host. After 3 days the characteristic zoosporangia of the parasite appeared. Occasionally encysted zoospores of the host were infected, each becoming enlarged and converted in entirety into a zoosporangium of the parasite (Fig. 7*g*). After several attempts it was found possible to infect a culture of the host growing on dry oatmeal agar (i.e. without surface water), and when this was flooded it produced a crop of zoosporangia of the parasite after several hours. It was not possible, however, to maintain the parasite in culture by this means. It was established that the fungus infecting both the field and culture material of *Z. insidians* was one and the same by cross-inoculating from infected culture material on to uninfected field material and vice versa. In both cases the characteristic zoosporangia of the parasite appeared in the inoculated (uninfected) material after a few days, and the type of zoosporangia corresponded closely to that found in the naturally infected material.

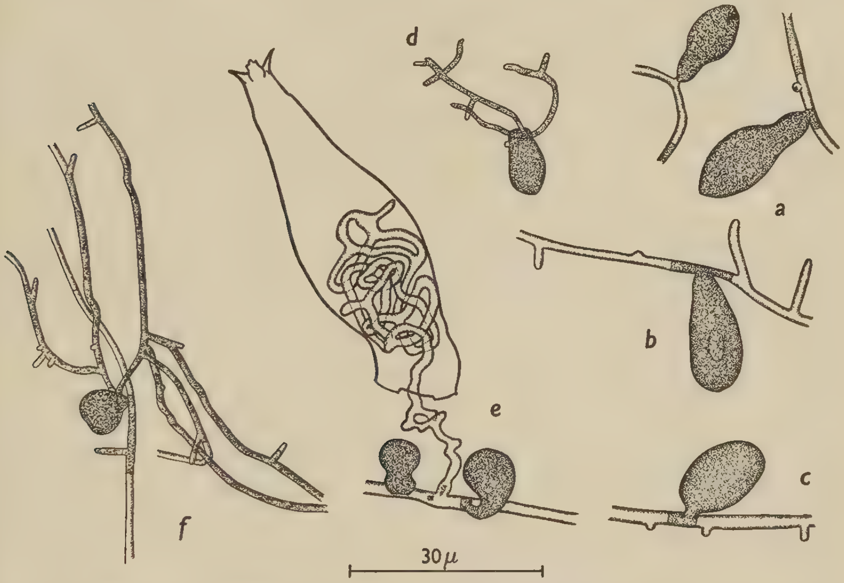

Fig. 8. Field material of *Zoophagus insidians* infected by *Rozellopsis inflata* showing how the lateral capturing organs of the former are converted into the zoosporangia of the latter.

Inoculations were also made on cultures of a number of unidentified species of *Pythium* belonging to the Aphragmium section. Although the inoculations were successful, infection was slightly less marked than with *Zoophagus*. Similar attempts to transfer the parasite to *Pythium intermedium* were successful, but there was no conspicuous hypertrophy, as was reported by Butler (1907). (This may well have been because the strain of *P. intermedium* used did not produce zoosporangia like those described in Butler's account.) The chains of sporangia produced rarely gave rise to zoospores, each sporangium usually germinating direct to form a hypha. Infected sporangia differed little in size from normal ones, but were much more opaque in appearance. The entire sporangium was then converted into the zoosporangium of *Rozellopsis inflata*.

Attempts to transfer the parasite to a pure culture of *Phytophthora megasperma* (a host of *Rozellopsis waterhousei*) were unsuccessful, even when a very heavily infected inoculum was used. Thus it seems that *R. inflata* is not identical with *R. waterhousei* which Waterhouse (private communication) reports as being restricted to species of *Phytophthora*.

Rozellopsis inflata, as described above, shows certain differences from that described by Butler (1907). The zoospores are nearly spherical, at least outside the zoosporangium, and not reniform. Oil drops are not mentioned by Butler, but his description of the developmental stages of the zoosporangium was somewhat incomplete. In the present studies of *R. inflata*, it was found that *Zoophagus insidians* was more easily parasitized than *Pythium intermedium*. Little is yet known about the factors which govern infection, and the above differences cannot be regarded as adequate to warrant the separation of the parasite on *Zoophagus insidians* as a distinct species. It should remain therefore under the binomial of *Rozellopsis inflata* Karling.

Rozellopsis was proposed by Karling in 1942 (see Karling 1943) for *Rozella*-like species with biflagellate zoospores. Of the four species there are two in which the sporangia occur singly, namely, *Rozellopsis inflata* (Butler) Karling parasitic on *Pythium intermedium*, and *Rozellopsis waterhousei* Karling parasitic on species of *Phytophthora*. In the other two species, *Rozellopsis septigena* (Fischer) Karling, parasitic on *Saprolegnia*, and *Rozellopsis simulans* (Fischer) Karling, parasitic on *Achlya*, the sporangia occur in chains because of septation of the infected host hyphae. The host range of *Rozellopsis inflata* has, by the present studies, been extended to include *Zoophagus insidians*. The similarity between *Rozellopsis waterhousei* and *R. inflata* are so marked that they obviously belong together, differing mainly in the host range. *R. septigena* and *R. simulans* would also seem to be closely related, the main difference being in the host range. The relationship between the two groups, however, is less obvious, but the marked similarity between the developmental stages leading to zoospore formation in *R. waterhousei* (Waterhouse, 1940), *R. inflata* and *R. septigena* (Prowse, 1951) indicates that they are related and that all four species are justifiably included in the same genus.

The genus *Rozellopsis* has been included with *Woronina* in the Woroninaceae, but the relationship between the two genera is open to doubt. The family has been used by Karling (1943) 'largely as a dumping-ground for biflagellate species having plasmodial stages'. *W. polycystis*, which closely resembles *Octomyxa*, has been shown by Dr Barrett of the University of California to be a member of the Plasmodiophorales (private communication from Prof. Karling), but his findings have not yet been published. *Woronina glomerata* shows distinct animal-like phases, engulfing chloroplasts and solid particles, and is reminiscent of the Protomyxa.

Rozellopsis, on the other hand, shows certain differences from the

Plasmodiophorales. The plasmodium, if it occurs at all, must be finely dispersed throughout the infected host protoplasm, and the host and parasite protoplasm are apparently indistinguishable, at least by ordinary staining technique. In the Plasmodiophorales the plasmodium is clearly distinguishable from the protoplasm of the host. In addition, in *Rozellopsis* the zoospore case is left attached to the host wall after infection, whereas in the Plasmodiophorales the infecting organism enters as a clearly definable naked mass without any zoospore case. Again the evidence points to lateral insertion of the flagella in the zoospores of *Rozellopsis*, not anterior as in the Plasmodiophorales. For these reasons it seems unwise to include *Rozellopsis* in the Plasmodiophorales.

Rozellopsis resembles *Olpidiopsis* in the insertion of the flagella and the fact that the zoospore case is left attached to the host wall after infection. The zoosporangium might be compared to an enlarged sporangium of *Olpidiopsis* which has completely filled the swollen end of the infected host hypha. In *Olpidiopsis*, however, the mature sporangium has a definite wall clearly separate from that of the host, while in *Rozellopsis* the wall of the sporangium is so thin, and adheres so closely to that of the host that it can only be demonstrated by plasmolysis. Furthermore, during sporogenesis in *Olpidiopsis* the thallus is clearly distinguishable within the swollen tip of the infected host hypha, and there are none of the cleavage stages so characteristic of *Rozellopsis*.

From the above considerations it would seem that *Rozellopsis* cannot satisfactorily be included in the Plasmodiophorales, Woroninaceae, or Olpidiopsidaceae, and might be better regarded as a distinct family within the Phycomycetes, at least at present.

This paper formed part of a thesis for the Ph.D. degree of the University of London.

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THE NIDULARIACEAE OF THE WEST INDIES

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(With 2 Text-figures)

Thirty collections of West Indian fungi belonging to the Nidulariaceae in the Herbarium of the Royal Botanic Gardens at Kew, the National Museum in Paris and in the herbarium of H. J. Brodie, Indiana University, have been studied and assigned to thirteen species. No new species are described. Although three additional species have previously been reported from the area, these are not included because the collections have not been seen by the writers and because of the possibility of misidentification of material on which the records were based.

Especially noteworthy is the occurrence of *Nidula niveo-tomentosa* (Henn.) Lloyd on the Blue Mountains in Jamaica, as this fungus occurs on continental North America only on the west coast from California to British Columbia. *Crucibulum vulgare* Tul. has apparently never been found in the West Indies.

A key to the West Indian Nidulariaceae is included, and descriptions and distribution records are given.

The following account of the Nidulariaceae of the West Indies is based largely on material in the Herbarium of the Royal Botanic Gardens, Kew. Much more study of fresh material from this area is needed because several of the common species are so variable that it is frequently very difficult to place a collection in one or another of the closely related 'species'. This is true, for example, in the complex involving *Cyathus pallidus* Berk. & Curt. Perhaps only study of the fungi in culture will settle the problems. Meanwhile, the following notes and key may be of use in making determinations of these interesting fungi.

The monograph of the group by Lloyd (1906) is doubtless the most useful and best illustrated account of the bird's nest fungi to date. Keys for the identification of some of the species listed below are given by White (1902) and by Coker & Couch (1928). A key to the West Indian species is included here in the belief that the notes would be made more valuable for collectors. As with all keys, some difficulty may be encountered by those unfamiliar with the morphology of the Nidulariaceae. The *tunica* of the peridiole is, in most species of *Cyathus*, a very thin white or pale brown membrane of loosely aggregated hyphae (Fig. 1A). It is not always present and, when present, may be so thin as to be lost in sectioning a peridiole or remain only as a few colourless hyphae. The *cortex*, on the other hand, is a dark hard structure composed either of one layer (i.e. homogeneous), or of two layers which tend to split apart upon sectioning. These points are mentioned lest the presence of a tunica plus a one-layered cortex be interpreted as representing a double-layered cortex. Double cortex without tunica is exemplified by *Cyathus stercoreus* (Schw.) De Toni as illustrated in Fig. 1 B; the single-layered cortex plus tunica is seen in *C. pallidus* (Fig. 1 A).

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* John Simon Guggenheim Memorial Foundation Fellow, 1952.

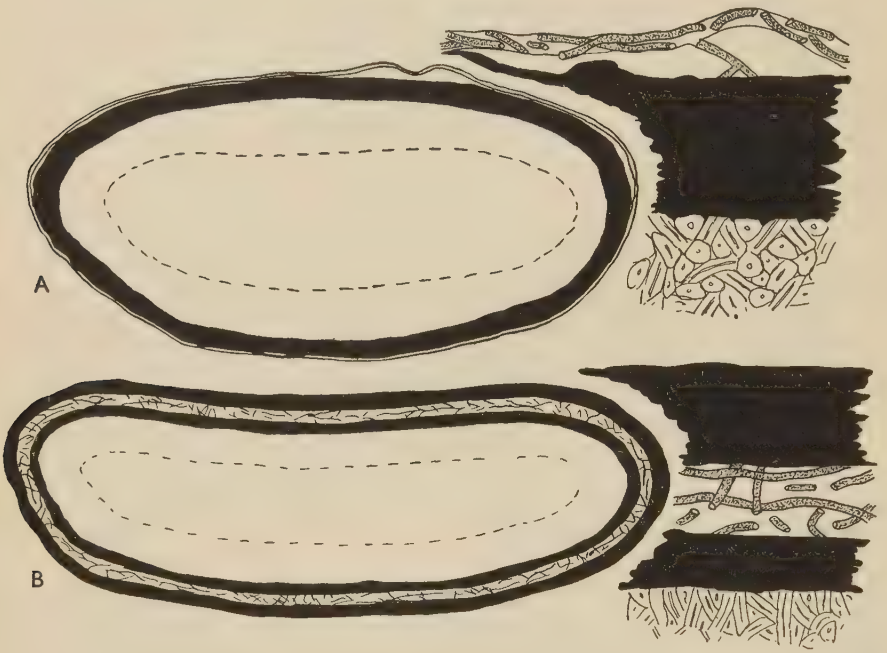

Fig. 1. Diagrammatic sections of Peridioles, × 75, details on right, × 500. A. With a one-layered cortex and tunica (*C pallidus*). B. With a double cortex and no tunica (*C. stercoreus*).

A further point of possible confusion is that the term tunica was applied by Tulasne (1844) to the hard cortical layer, whereas Lloyd (1906) and subsequent workers differentiated between the delicate and often evanescent tunica, as defined above, and the dark hard cortex. The latter practice has been followed in the present paper.

The terms *plicate* and *fluted* are used in the key instead of the usual *striate*, as the latter may connote fine linear grooves, whereas the fruit bodies are really often broadly ridged or folded.

Specimens referred to are in the Kew Herbarium unless otherwise indicated.

In addition to species given in the list that follows, four others have previously been reported to occur in the West Indies. Because the collections in question have not been seen by the writers and because of the possiblity of misidentification in some instances, the following are not included as authentic records: *C. striatus* (Huds.) Willd. ex Pers., *C. montagnei* Tul. and *C. olla* Pers. Several collections from Nassau named *C. striatus* which are, in fact, *C. poeppigii* have been examined and most collections seen of *C. olla* so named from the West Indies have turned out to be *C. pallidus*. However, since *C. olla* is present in South America and southern United States, it should be looked for in the West Indies and it has been included in the key to species given below.

The absence of *Crucibulum vulgare* Tul. from the West Indies is noteworthy, although Lloyd (1906) reported that he had never obtained this fungus from the tropics proper. *Nidula niveo-tomentosa* (Henn.) Lloyd occurs in North America only on the west coast from California to British Columbia. The appearance of this species on the Blue Mountains, Jamaica, is therefore surprising and constitutes one of those patterns of distribution which are difficult to explain.

Key to the Species of Nidulariaceae of the West Indies

A. Peridioles not attached to inner wall of peridium (cup); peridioles small, numerous, gelatinous when moist. **NIDULA** (**Nidula niveo-tomentosa** (13))

A_1. Peridioles attached to inner wall of peridium; peridioles about 2 mm. wide, few, 12–20 in number, not markedly gelatinous when moist; peridium composed of three distinct layers. **CYATHUS**

a. Cups distinctly plicate or fluted inside and outside; outer fluting often hidden by hairy surface.

b. Spores very small, 5–6 × 7–8 μ; cortex of peridiole composed of a single layer. **Cyathus berkeleyanus** (3)

b_1. Spores at least 10 μ long, mostly longer; cortex of peridiole two-layered.

c. Plication or fluting fine, the grooves about 0·5 mm. apart; spores at least 30 μ in length.

d. Cups moderately large; spores 30–50 μ. **C. poeppigii** (1)

d_1. Cups small, 2·5–3 mm., spores 16 × 44 μ. **C. costatus** (12)

c_1. Plication or fluting coarse, the grooves about 0·75–1 mm. apart; spores 10–12 × 16–22 μ. **C. limbatus** (2)

a_1. Cups smooth inside and outside or, if plicate inside, only faintly so.

d. Cortex or wall of peridiole composed of only one layer as seen in section.

e. Spores very small, 4 × 5–6 μ; cups dark brown, evenly woolly. **C. microsporus** (10)

e_1. Spores 8–16 μ; cups straw-coloured to pale fawn.

f. Cups provided with long shaggy hairs, not plicate.

g. Cups small, thin-textured, crucible-shaped, with long rigid hairs. **C. pallidus** (5)

g_1. Cups larger, 6–8 mm. high, obconic, the tomentum cohering in tufts or nodules. **C. intermedius** (6)

f_1. Cups comparatively smooth, not provided with long hairs, not plicate, often flaring at mouth. **C. olla***

d_1. Cortex or wall of peridiole composed of two layers as seen in section.

h. Peridioles covered on upper side with thin, silvery tunica.

i. Cups with coarse spreading hairs on the outside, spores elliptical, 12–14 × 16–22 μ. **C. triplex** (7)

i_1. Cups covered on outside with fine even tomentum, very dark brown.

j. Spores elliptical, 12–16 × 24–32 μ. **C. earlei** (8)

j_1. Spores globose, 7–9 μ. **C. canna** (9)

h_1. Peridioles shiny black, without tunica; fungus usually coprophilous.

j. Spores large, subglobose, 30–40 μ; cups variable as to size and colour, commonly 6–7 mm. in diameter and light tan. **C. stercoreus** (4)

j_1. Spores smaller, elliptical, 8–16 μ; cups small, about 3 mm. in diameter. **C. fimicola** (11)

* *C. olla* not recorded for the West Indies.

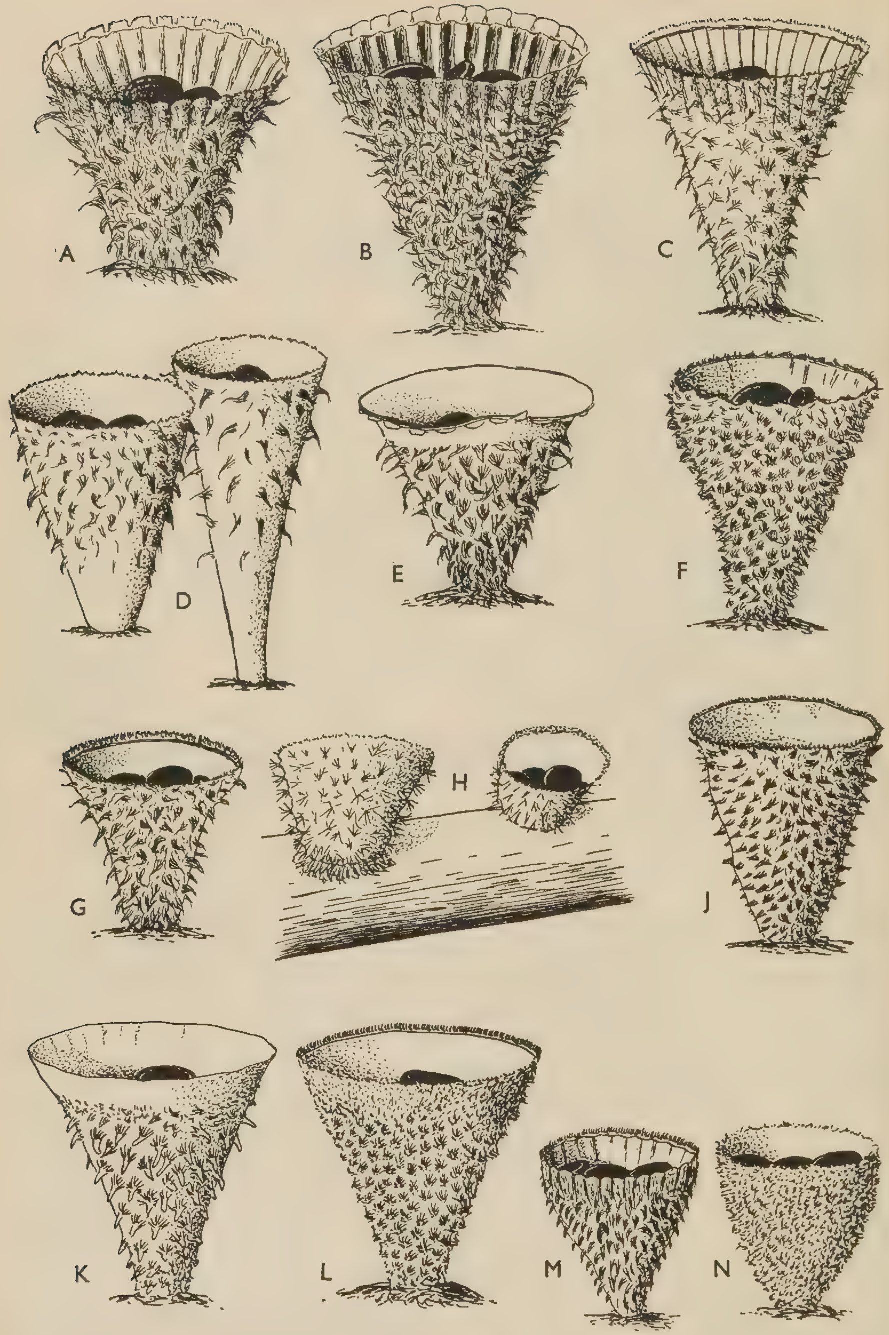

Fig. 2. Habit sketches of West Indian Nidulariaceae, × 5. A. *Cyathus poeppigii* Tul. from Florida. B. *C. limbatus* Tul. from British Guiana. C. *C. berkeleyanus* (Tul.) Lloyd from Dominica. D. *C. stercoreus* (Schw.) De Toni. Left from Jamaica, right the slender form called *C. lesueurii* Tul. from Bloomington, Indiana. E. *C. pallidus* B. & C. from Jamaica. F. *C. intermedius* (Mont.) Tul. from Nassau, Bahamas. G. *C. microsporus* Tul. from San Domingo. H. *Nidula niveo-tomentosa* (Henn.) Lloyd from Jamaica. J. *Cyathus triplex* Lloyd from British Guiana. K. *C. canna* Lloyd from the type collection, Barbados. L. *C. earlei* Lloyd from the type collection, Cuba. M. *C.* '*costatus* Lloyd' from Puerto Rico. N. *Cyathus* sp. called '*C. fimicola* Lloyd' from Puerto Rico.

NOTES ON THE SPECIES

CYATHUS Haller, *Stirp. Helvet*, 3, 127, 1768; ex Pers. *Syn. Meth. Fung.*, p. 237, 1801

1. **Cyathus poeppigii** Tul., *Ann. sci. Nat.* III, **1**, 77, 1844.
Cyathus sulcatus Kalchbr, *Grevillea*, **10**, 107, 1882.

One of the most widely distributed species in the tropics. *Cups* dark brown, felted or shaggy, obconic, 6–8 mm. high and 6 mm. wide at the mouth, both outer and inner surfaces deeply fluted or plicate, the plicae being about 0·5 mm. apart, in clustered masses on rotten wood. *Peridioles* black and shiny. *Spores* very large, elliptical to globose, usually 20–28 × 30–42 μ. In West Indian material, spores are often somewhat smaller. (Fig. 2A.)

C. plicatulus is an unpublished name applied by Poeppig to his exsiccati from Cuba and is usually cited in synonymy. *Nidularia plicata* Fries may be a synonym, but we have not seen the type, and the brief description does not make identification possible.

Collections seen: (Type) Cuba, rotten wood on ground, Poeppig exsicc. no. 47, 1824, in Nat. Mus. Paris; Nassau, Hog Island, Bahamas, F. Shuttleworth, 18 July 1949 (in herbarium H. J. Brodie); Cuba, F. G. Lea, no. 73; Trinidad, Port of Spain, Botanic Gardens, W. E. Broadway, 8 December 1907; Antigua, Dr Nicholson, Herb. Hooker.

2. **Cyathus limbatus** Tul., *Ann. sci. Nat.* III, **1**, 78, 1844.
Nidularia striata var, *pusilla* Berk., *Ann. Nat. Hist.* III, 397, 1839.

Another common species in a general way resembling *Cyathus poeppigii*. The following features are distinctive. *Cups* dark brown, large and robust, 7–10 mm. high, 6–7 mm. wide at the mouth, outer and inner surfaces fluted, the ridges wider apart (0·75–1 mm.) than in *C. poeppigii*. *Peridioles* deep brown to black, and shiny. *Spores* 10 × 15 μ in the type but in West Indian material vary from 10 × 16 μ to 12 × 22 μ. This fungus has a conspicuous ball or emplacement of mycelium at its base. When young, fruit bodies may be so hirsute as to obscure the external fluting. Common on wood debris and bare ground. (Fig. 2B.)

Collections seen: (Type) British Guiana, Herb. Hooker; Jamaica, St Andrews, Upper Mountain, C. B. Lewis, 24 October 1950 (in herbarium H. J. Brodie); Cuba, Wright's nos. 240, 682, 683; Cuba, Fungi Cubenses Wrightiani, no. 515.

3. **Cyathus berkeleyanus** (Tul.) Lloyd, *Lloyd Myc. Writ.* **2**, Nidulariaceae, p. 25, fig. 17, December 1906.
Cyathus microsporus var. *berkeleyanus* Tul., *Ann. sci. Nat.* III, **1**, 74, 1844.
Cyathia berkeleyana (Tul.) White, *Bull. Torrey bot. Cl.* **29**, 258, 1902.

Tulasne considered this species a variety of *Cyathus microsporus*. White (1902) and, later, Lloyd (1906) pointed out that *C. berkeleyanus* bears little resemblance to *C. microsporus* and should be held as a distinct species. Macroscopically, the plants resemble small specimens of *C. limbatus* or

C. poeppigii from which they differ markedly in microscopic features. From other fluted species of *Cyathus*, *C. berkeleyanus* may be distinguished by its very small sub-globose *spores* which measure 5–6 × 7–8 μ. *Cups* dark brown, hirsute when young, becoming smooth in age; outside and inside plicate. *Peridioles* dark brown 2 mm. in diameter and with thin tunica. Peridiole wall (cortex) composed of but a single layer of hyphae, another point of difference from *C. limbatus* and *C. poeppigii*. Lloyd (1906) mentions that this species is abundant in Tobago, and White (1902) reported it from Jamaica. (Fig. 2C.)

Collections seen: (Type) Rio de Janeiro, Charles Darwin, 1832; Dominica Island, on bamboo plant pots, Botanic Gardens, E. M. Wakefield, 2 October 1920.

4. **Cyathus stercoreus** (Schw.) De Toni in Saccardo, *Syll. Fung.* **7**, 40, 1888.

Nidularia stercorea Schw., *Trans. Amer. phil. Soc.* **4**, 253, 1834.
N. melanosperma Schw., *Trans. Amer. phil. Soc.* **4**, 253, 1834.
Cyathus subiculosus Kickx., *Bull. Acad. roy. Sci. Belles Lettres Bruxelles*, **8**, 78, 1841.
C. lesueurii Tul., *Ann. Sci. nat.* III, **1**, 79, 1844.
C. wrightii Berk., *Grevillea*, **2**, 34, 1873.
C. melanospermus De Toni in Saccardo, *Syll. Fung.* **7**, 42, 1888.
C. puiggarii Speg., *Bolet. Acad. Nac. Ciendas Cordoba*, **11**, 474, 1889.
C. baileyi Mass., *Grevillea*, **21**, 3, 1892.
C. dimorphus Cobb., *Agric. Gaz. N.S.W.* **3**, 1005, 1893 (for December 1896).
C. affinis Pat., *Bull. Soc. mycol. Fr.* **11**, 87, 1895.
C. plumbagineus McAlp., *Proc. Linn. Soc. N.S.W.* **21**, 104, 1896.
C. rufipes Ell. et Ev., *Bull. Torrey bot. Cl.* **24**, 125, 1897.
Cyathia melanosperma (Schw.) White, *Bull. Torrey bot. Cl.* **29**, 262, 1902.
C. rufipes (Ell. et Ev.) White, *Bull. Torrey bot. Cl.* **29**, 265, 1902.
C. wrightii (Berk.) White, *Bull. Torrey bot. Cl.* **29**, 265, 1902.
C. stercorea (Schw.) White, *Bull. Torrey bot. Cl.* **29**, 266, 1902.

This coprophilous species is of world-wide distribution and extremely variable, especially as to size and colour of the cups. This has been pointed out by Lloyd (1906) and discussed fully by Brodie (1948). *Cups* covered with shaggy woolly hairs which may become matted in age or worn off, not plicate, bluish black to lead colour inside. *Peridioles* black and in section showing a striking double-layered cortex (Fig. 1B). *Spores* large, subglobose and varying much in size up to 40 μ, although in Jamaican material they are seldom more than 30 μ. The plants often grow in great masses on manure or manured soil. (Fig. 2D.)

Collections seen: Jamaica, St Andrew, Blue Mountains, A. Barry, August 1943; Bermuda, Hinson's Island, Seaver and Waterston, 5 December 1938; Cuba, C. Wright no. 686 and issued as Fungi Cubenses Wrightiani no. 519.

5. **Cyathus pallidus** Berk. et Curt., *J. Linn. Soc. Bot.* **10**, 346, 1869.
Cyathia pallida (B. et C.) White, *Bull. Torrey bot. Cl.* **29**, 263, 1902.
Cyathus sphaerosporus Lloyd, *Lloyd Myc. Writ.* **2**, Nidulariaceae, p. 23, 1906.

Although *C. pallidus* is easily recognized in its commonest and typical form, it is an extremely variable species. As Lloyd (1906) has suggested, *C. pallidus*, *C. intermedius* (Mont.) Tul. and *C. triplex* probably constitute a species complex including many intermediate forms. Lloyd himself finally decided that his *C. sphaerosporus* is not distinguishable from *C. pallidus* and further study may show that the complex represents but one variable species. A number of collections have been examined but it is certain that the group needs further study. Meanwhile, it seems possible to recognize two species belonging to it in the West Indies.

The true *Cyathus pallidus* has *cups* pale buff to fawn coloured, 5–7 mm. high and about as wide at the mouth, crucible-like, i.e. with strongly curved sides and narrow base. The thin texture and friable nature of the cups are noteworthy features. Sides not at all plicate and the outer surface covered with long downward-bent hairs. *Peridioles* dark grey to black, 2 mm. in diameter, with thin tunica and single-layered cortex (Fig. 1 A). The *spores* small elliptical $4–7 \times 8–9\,\mu$, $7{\cdot}5–8{\cdot}5 \times 10–15\,\mu$. (Fig. 2 E.)

In another form of *C. pallidus* the fruit body is darker in colour, in extreme cases as deep as Mummy Brown, and the spores are larger than in the type. As these two forms may occur side by side in the same collection, it seems probable that they are variants, but only study of the fungi in culture will solve the problem. The darker forms have been confused in herbaria with *C. microsporus* Tul. The latter species, however, has very small spores and, although woolly, is without the long stiff hairs of *C. pallidus*. The fungus is common on dead fallen sticks.

Collections seen: (Type) Cuba, on Eucalyptus roots, C. Wright, no. 684 and issued as Fungi Cubenses Wrightiani no. 517; Nassau, on ground, F. Shuttleworth, 18 July 1949 (in herbarium H. J. Brodie); Jamaica, D. Masters, received Kew, 1905.

6. **Cyathus intermedius** (Mont.) Tul., *Ann. Sci. nat.* III, **1**, 72, 1844.
Nidularia intermedia Mont. in Sagra, *Hist. Phy. Pol. Cuba*, p. 321, 1838–42.
Cyathia intermedia (Mont.) White, *Bull. Torrey bot. Cl.* **29**, 258, 1902.

Cups 6–8 mm. high and 5–7 mm. wide at the mouth. Commonly pale fawn but sometimes darker, obconic with a slender base, the sides being much straighter than in *C. pallidus*, externally with appressed hairs, and, when the fruit body is young, these hairs cohere in nodules or tufts. The latter characteristic is often difficult to discern in old or rubbed specimens. The basal mycelium (emplacement) is large in comparison with the size of the cups. *Peridioles* with thin tunica as in *C. pallidus*. *Spores* subglobose, $9 \times 16\,\mu$ in the type, in all specimens examined $8–10 \times 12–16\,\mu$. Spores often vary much in a single peridiole. Common on dead fallen sticks. (Fig. 2 F.)

Collections seen: (Type) Cuba, San Marcos, R. Sagra (in Nat. Mus.

Paris); (co-types) Cuba, San Marcos, on sandy soil, R. Sagra; Bermuda, Montrose, on fallen sticks, H. H. Whetzel, 11 October 1921; Bahamas, Nassau, on rotting wood, L. J. K. Brace, 7 November 1929.

7. **Cyathus triplex** Lloyd in *Lloyd Myc. Writ.* **2**, Nidulariaceae, p. 23, 1906.

This species generally resembles *C. pallidus*, from which it may be distinguished by its dark colour, more scabrous hairs, larger spores and the double cortex of the peridiole. Only a single collection has been recorded from the West Indies, but it occurs in British Guiana and doubtless will be found again in the West Indies. The species was reported from Porto Rico by Overholts (1926) but his material has not been seen by us. (Fig. 2J.)

Collection seen: Holmia, Potaro River, British Guiana, A. W. Bartlett 8709, December 1908.

8. **Cyathus earlei** Lloyd in *Lloyd Myc. Writ.* **2**, Nidulariaceae, p. 26, 1906.

We have seen only a portion of the type collection of this species which is supposedly rare. It is included here because two of the three known collections are from the West Indies. An abbreviated form of Lloyd's (1906) description follows:

Cups campanulate, rigid, 7–8 × 6–8 mm., dark, blackish brown; externally even, scabrous, with short tomentum; internally smooth or faintly striate, white, contrasting with the dark exterior. *Peridioles* covered on the upper side with the thin tunica. Cortex thick, double, the outer thin, composed of small fibrils. *Spores* elliptical or slightly oval-elliptical 12 × 24–32 μ. This species in its shape and rigid cups is related to *C. vernicosus* (*C. olla*), differing much in colour and spores. (Fig. 2L.)

Lloyd reported the following specimens: Cuba, Santiago de las Vegas, F. S. Earle, 1904; Hawaii, Honolulu, F. W. Terry. There is a third collection in the Lloyd herbarium—Puerto Rico, Rio Piedras, John A. Stevenson.

9. **Cyathus canna** Lloyd in *Lloyd Myc. Writ.* **2**, Nidulariaceae, p. 27, 1906.

Another apparently rare species known from two collections only, one from the type locality (Barbados) and one from Mauritius. Again Lloyd's description is quoted:

Cups campanulate, rigid, 7–8 × 6–8 mm., dark brown; externally even, scabrous with short tomentum; internally smooth, even, white, as if covered with a thin layer of whitewash. *Peridioles* covered on the upper side with a silvery thin tunica. Cortex double, the outer, thin, composed of small fibrils. *Spores* small, globose, 7–9 μ.

Writing many years later of the Mauritius collection, Lloyd (1925) commented: 'they [the cups] resemble those of *vernicosus* (*C. olla*) but are even and white within. The globose spores, 8 μ, are its feature. It is evidently a rare species.' (Fig. 2K.)

This fungus should be looked for again in Barbados and elsewhere in the West Indies.

10. **Cyathus microsporus** Tul., *Ann. Sci. nat.* III, **1**, 73, 1844.

This species is not readily distinguished from other small dark brown species of *Cyathus*. *Cups* 5–7 mm. high and about 6 mm. wide at the mouth. Obconic with a slender base and inconspicuous emplacement; externally not plicate, sometimes shaggy or covered with appressed hairs; inside, slightly lighter in colour, smooth or faintly ridged (never definitely plicate). *Peridioles* black, about 2 mm. in diameter, tunica thin, cortex single-layered as seen in section. *Spores* 4 × 5–6 μ. (Fig. 2 G.)

Some specimens from Cuba are very small (4 mm. high) and fawn or buff, not dark brown.

It is possible that more than one species is included within the known variable collections of *C. microsporus*. Lloyd (1915) referred collections from Florida to this species and concluded that, as they resembled closely *C. hookeri* Berk., the latter should be considered a synonym of *C. microsporus*. Berkeley's species occurs in the Eastern Hemisphere, has larger cups and larger spores than those of *C. microsporus* and we are inclined to agree with Cunningham (1924) who retained *C. hookeri* as a separate species. Whether or not it occurs in the West Indies is not known.

Collections seen: (Type) San Domingo, Poiteau (in Nat. Mus. Paris); (co-types) San Domingo, Sallé, ex Herb. Cooke; Cuba, C. Wright (in Nat. Mus. Paris).

11. **Cyathus fimicola** Lloyd, in herb., unpubl.
(non *C. fimicola* Berk., *J. Linn. Soc.* **18**, 387 1881.)

Lloyd's unpublished description was printed by Stevenson & Cash (1936). The name *C. fimicola* was not validly published as it lacked a Latin diagnosis and it was, in any case, illegitimate as a later homonym of *C. fimicola* Berk. When the species has been re-collected and substantiated it must receive a new name. Judging by part of the type collection kindly loaned to Kew by Mr J. S. Stevenson it is a good species, perhaps overlooked because of its small size. It is a small pale coprophilous fungus (2–3 × 4–5 mm.) with black peridioles and spores 8 × 16 μ. The 'type' specimens were collected by Bruce Fink, Yanco, Puerto Rico, December 1915 and are in the Lloyd collection. (Fig. 2 N.)

12. **Cyathus costatus** Lloyd ex Stevenson & Cash, *Bull. Lloyd Libr.* no. 35, Myc. Ser. **8**, 201, 1936.

Cyathus costatus was also not validly published by Stevenson & Cash (1936). When it is re-collected, a validating diagnosis should be published, preferably retaining Lloyd's specific epithet.

The fungus grows on manure in the tropics. According to Lloyd's manuscript note published by Stevenson & Cash (1936), the fungus is characterized as follows:

'*Cups* small, dark, about 2·5 × 3 mm. in diameter, covered with dark strigose hairs, strongly ribbed, striate. *Peridiole* small, 1 mm., black. *Spores* about 16 × 44 μ, elliptical.... Its striate cups and large spores place it close to the common tropical species *C. plicatulus* (called also *C. poeppigii*), but the cups are only about one-half as large, the striations much coarser, and its habitat on manure entirely different.' (Fig. 2 M.)

The 'type' locality was Mayaguez, Puerto Rico, and we have seen only a fragment of this collection.

NIDULA White, *Bull. Torrey bot. Cl.* **29**, 271, 1902

13. **Nidula niveo-tomentosa** (Henn.) Lloyd, *Lloyd Myc. Writ.* **3**, 455, 1910.

Cyathus niveo-tomentosus Henn., *Hedwigia*, **37**, 274, 1898.
Nidula microcarpa Peck ex White, *Bull. Torrey bot. Cl.* **29**, 272, 1902.
N. microcarpa var. *rugispora* White, *Bull. Torrey bot. Cl.* **29**, 272, 1902.

Only one specimen of this fungus collected in the West Indies has been examined. It comes from the Blue Mountains, Jamaica. A full description of the species (under the name *N. microcarpa*) has been given by Brodie (1951). It is fairly common on the west coast of North America and has been reported from Australia, New Zealand and Japan.

Lloyd (1923) ultimately decided that it is not possible to distinguish this species from *N. emodensis* (Berk.) Lloyd. Cunningham (1924) accepted the synonymy when writing of the New Zealand Nidulariaceae. However, we have examined the types of *N. emodensis* at Kew and co-types in Paris and are at present of the opinion that these specimens are distinct from *N. niveo-tomentosa*. *N. emodensis* was found at Sikkim in the Indian Himalayas. The type specimens are generally more massive than those of *N. niveo-tomentosa*, much darker in colour (fawn, golden or rusty) and externally more felty. Only study of more material from the Eastern Hemisphere will settle the question as to whether or not the two forms are distinct. *N. emodensis* in the strict sense indicated above has not been seen by us in West Indian material. (Fig. 2H.)

Collection seen: Jamaica, High Peak, Blue Mountains, St Andrew, on fern rachis, C. B. Lewis (no. 50*a*), 29 March 1946.

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MASTIGOSPORIUM DESCHAMPSIAE JØRSTAD IN GREAT BRITAIN

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(With 2 Text-figures)

Mastigosporium deschampsiae Jørstad is reported for the first time in Great Britain, as a cause of a leaf spot on *Deschampsia caespitosa* (L.) Beauv. at Wicken Fen, Cambridgeshire. The symptoms resemble those of other species of *Mastigosporium* on grasses and of *M. album* Riess on *Deschampsia caespitosa.* High humidity and low temperature favour the spread of the fungus. No appreciable growth in culture occurs above 20° C., but characteristic colonies are produced at 5° C. on a variety of media. Normal conidia are formed in culture but tend to become distorted with increase of temperature. Inoculation with spores failed to produce symptoms on *Alopecurus pratensis* L. or *Dactylis glomerata* L. Lesions experimentally produced on the host grass took 3 weeks to reach conidial production. Examination of herbarium material shows that this species is distinct from collections made by Libert on the same host, which are true *Mastigosporium album.*

Jørstad (1947) described a new species of *Mastigosporium*, *M. deschampsiae*, as the cause of a leaf spot of *Deschampsia caespitosa* (L.) Beauv. in Norway. He recorded it from six localities during 1885–1931. In November 1948 this fungus was found for the first time outside Norway at Wicken Fen, Cambridgeshire, where *D. caespitosa* is fairly abundant on the paths alongside the dykes. The determination of this collection has been verified by Prof. Jørstad, who states that the spores are on average longer and broader than the type. The other three species of *Mastigosporium*, *M. album* Riess, *M. rubricosum* (Dearn. & Barth.) Nannf. and *M. cylindricum* Sprague found in this country are dealt with by Bollard (1950) and some observations are now reported on the occurrence and culture of *M. deschampsiae* Jørstad.

SYMPTOMS

The leaf spots caused by *M. deschampsiae* correspond closely with those of the other species of the genus on various grasses. They are found on all parts of the leaf blade and are up to 3 by 1 mm., being delimited by the veins. The earliest stages are purplish brown, but later a fawn-coloured centre appears, where, under favourable conditions, the heaped-up conidia can be seen. A yellowing of the leaf tissue often occurs outside the brown area, whilst the spots may become confluent if the infection is heavy. No differences have been seen between the symptoms on the old and young leaves, but in the dead leaves the lesions extend their borders as spreading and confluent dark brown lines. The heavily infected tufts of the host are greatly reduced in vigour and may even be killed, for dead tufts have been found with evidence of heavy attack. Premature death of the leaves is most marked in the autumn, when infection becomes much more intense.

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MASTIGOSPORIUM DESCHAMPSIAE JØRSTAD

The conidia of the Wicken Fen collections are hyaline phragmospores (40) 50–78 (84) × 17–28μ, 3 to 7, mostly 5-, septate, tapering bluntly at either end (Figs. 1, 2*g*–*h*). The individual cells are about twice as broad as long, with contents varying from strongly vacuolate to finely granular, depending on their age. Jørstad gives the measurements of the type as 40–68 × 15·5–20μ, 4- to 7-, mostly 6-, septate (Fig. 2*j*–*k*).

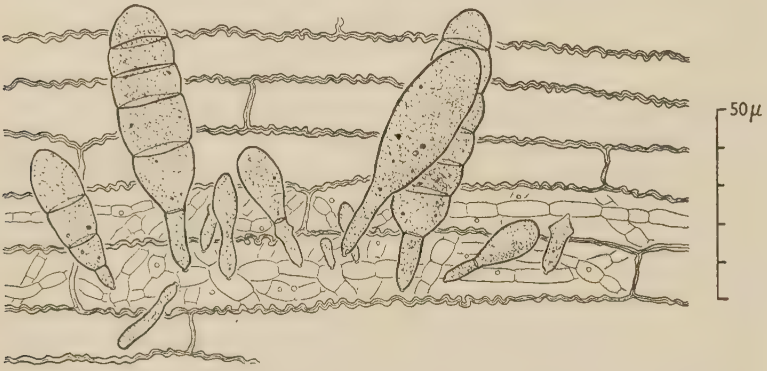

Fig. 1. Conidia of *Mastigosporium deschampsiae* developing from a single epidermal cell of *Deschampsia caespitosa*. × 500.

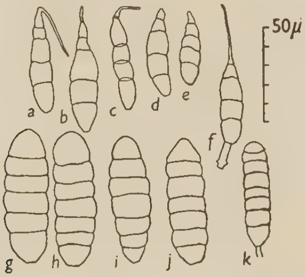

Fig. 2. Conidia of *Mastigosporium* spp. on *Deschampsia caespitosa*. × 250. *a*–*f*, *Mastigosporium album* Riess; *g*–*k*, *M. deschampsiae* Jørstad. *a*, *b*, ex de Thumen, Mycotheca Univ. No. 1872, leg. M. A. Libert, in Herb. Kew; *c*, after Sprague (1938), fig. O, p. 288, same exsicc. as figs. *a*, *b*; *d*, *e*, ex Roumeguère Fungi Gallici exsicc. No. 1434, in Herb. Kew; *f*, ex Herb. Jardin. Bot. Bruxelles (Libert No. Suppl. 538), in Herb. Kew; *g*, *h*, from Wicken Fen, Cambs, 28 April 1949, leg. P. K. C. Austwick; *i*, from Nord-Trondelag: Mo in Frosta, Norway, 5 August 1923, leg. I. Jørstad; *j*, *k*, after Jørstad (1947) fig. 2, p. 27.

OCCURRENCE AND SEASONAL VARIATION

The fungus has so far only been found at Wicken Fen where it is restricted to the banks of Malcarse, Drainers and Cross Dykes, although the grass itself occurs sporadically in other parts of the Fen. The reason for this is not clear, unless it is because of the recent introduction of the parasite, which has not yet had time to spread further afield, or else of its exceptional temperature/humidity relations. There is some evidence of an eastward spread of infection along the north side of Cross Dyke during the three years that observations have been made, but by 1952, the disease appeared to have vanished from the area alongside Drainers Dyke in which it had been prevalent in early 1949. All records have been made from an area of 380 m.^{2} bordered by the dykes named, these waterways themselves averaging 4 m. wide. *Deschampsia caespitosa* is abundant on all the narrow dykeside footpaths.

On counting the tufts of the host grass along the north side of Cross Dyke, about 20 % were found to be infected (i.e. showed definite lesions on the living leaves) on 1 April 1952. This level of infection seems to be fairly constant, but at the end of the dry summer of 1949, no new infections were to be seen, although by the following November lesions had begun to appear again. These observations correspond with those on the other species of *Mastigosporium* which require rainy or foggy weather for the spread and continuance of infection (Sprague, 1950), and also with the relatively low temperature limit for spore germination (Bollard, 1950).

PRODUCTION AND DISSEMINATION OF CONIDIA

When infected leaves are placed in a moist chamber for 24 hr., copious spore production occurs. The conidiophores are formed from slender filaments which grow individually through the cuticle from the intracellular hyphae in the epidermis of the leaf. These filaments dilate at their ends when 15–20μ high and form the terminal 5- to 7-septate conidia, which are easily detached by flooding the lesion with water. Subsequent formation of a second conidium occurs as described by Hughes (1951) in *M. rubricosum*, when the apex of the old conidiophores grows out and dilates again, leaving a small collar just beneath the new conidium (Fig. 1). Dissemination is undoubtedly as described by other authors, that is by the splashing of raindrops and by dewdrops running along the leaf-blades. Both of these methods would ensure a continual infection of the young leaves as they develop. It also seems likely that the spores are distributed by man, animals and birds.

CULTURAL CHARACTERISTICS AND EFFECT OF TEMPERATURE

Isolations were first made in January 1949 by streaking out a sterile water suspension of the conidia removed from a lesion with a flattened needle, on to 2 % malt-extract agar. Germination occurred in 2 days at room temperature, almost every cell producing a germ tube. Different media induce a range of growth rates, surface characters and colony colours, but the most marked effect is that of temperature. Colonies on 2 % malt agar at room temperature in winter are slow growing, dark orange, tending to become moist with conidia, at first even and smooth but later folded with lobed margins. In the laboratory in summer the rate of growth is greatly reduced and the colonies become heaped-up, folded and dry with buff-coloured surface hyphae, whilst growth to a 9 mm. diameter colony takes 5 weeks. When grown at 5° C., a diameter of 20 mm. is obtained in the same length of time, with the colonies becoming dull orange, fading to translucent in the broad, flat, even margins. The centre normally becomes much folded and nodular, blackening to form sclerotia-like bodies 0·5–1·5 mm. in diameter. No further development of these bodies was noted, and no comparable structures were found on dead leaves in the field. The effect of temperature on growth prevented successful subculturing at room temperature in summer for it was found that at 20° C. no extension into fresh medium took place, the only growth being a folding of the original inoculum. These observations bring *M. deschampsiae* in line with the species of *Mastigosporium* studied by Bollard (1950), who found optimum temperatures for growth of 15–20° C. *M. deschampsiae* seems most closely related to *M. album* in its temperature relations.

Growth on Czapek-Dox + 0·5 % yeast-extract agar (Warcup, 1951) and on *Deschampsia caespitosa* leaf-extract agar gave colonies of lighter colour than on malt agar, with more abundant white surface hyphae at 5° C. Conidia of a size agreeing well with those taken from leaf lesions are produced in large numbers by young colonies. Typical spores are formed at 5° C., but at higher temperatures some of the cells may collapse, and at 20° C. no spores are formed.

INOCULATION EXPERIMENTS

Inoculation experiments were only successful on the normal host, although attempts were made to infect plants of *Alopecurus pratensis* L. and *Dactylis glomerata* L. by spraying and by painting suspensions of the conidia produced in culture on to the leaves (Bollard, 1950). Small numbers of lesions appeared on the leaves of *Deschampsia caespitosa* after the plants had been kept under bell-jars for 48 hr. following inoculation, but infection always failed in the summer. Excised leaves of the normal host were also successfully inoculated whilst lying in Petri dishes on moist filter-paper. It was noted that each spot is apparently the result of infection by a single spore, and in these experiments took 3 weeks to reach spore production.

MASTIGOSPORIUM ALBUM RIESS ON *DESCHAMPSIA CAESPITOSA*

Previous to Jørstad (1947), only two records of *Mastigosporium* on *Deschampsia caespitosa* can be traced. The earliest is by Madame M. A. Libert who collected a fungus at Malmedy in the Ardennes, Belgium, between 1830 and 1837, and named it *Monothecium graminis* Libert, now apparently a nomen nudum. Sprague (1938) examined some of this collection and confirmed the determination as *Mastigosporium album*, but Jørstad (1947) stated that he lacked the facilities for deciding the relationship between this fungus and his new species. Collections in the Herbarium, Royal Botanic Gardens, Kew, were therefore examined and it is evident that Libert's material was distributed in several exsiccatae. Four packets bear the label 'Reliquae Libertiana No. 538', and from the herbaria of M. C. Cooke (two), C. Roumeguère (Fig. 2*d*, *e*), and the Jardin Botanique de Bruxelles (Fig. 2*f*). Another specimen, de Thümen Mycotheca Universalis No. 1872, is labelled 'Malmedy, leg. M. A. Libert' (Fig. 2*a*, *b*), and is duplicated in the Herbarium, British Museum (Natural History). There seems little doubt that this material is all derived from one source, even though it varies slightly in its state of preservation and the quantity of spores present.

The leaf spots in the Malmedy collections closely resemble those produced by *M. deschampsiae*, but the lesions bear the typical conidia of *M. album*, 40–63 × 11–17 μ, 3- to 4-septate, with filiform terminal appendages. Sprague's figure of a conidium from the material issued by de Thümen (No. 1872) shows a narrower shape and shorter appendage (Sprague, 1938, fig. O) (Fig. 2*c*).

The second record of *Mastigosporium* on *Deschampsia caespitosa* is by Sprague (1938), who obtained infections in sixteen out of 223 leaves inoculated with spores of *Mastigosporium album* sent to him by Miss K. Sampson from Wales.

Most of the observations in this account were made during the tenure of a Training Grant awarded by the Agricultural Research Council, and I am indebted to Dr W. J. Dowson for his help and encouragement. My thanks are also due to the National Trust for permission to work at Wicken Fen. The collections in the Herbarium, Royal Botanic Gardens, Kew, were examined by kind permission of the Director, and those in the British Museum (Natural History) by the courtesy of the Keeper of Botany. Material from Wicken Fen, Cambridgeshire, has been deposited in the herbaria of the Royal Botanic Gardens, Kew, the University of Cambridge, and the Commonwealth Mycological Institute (Herb. I.M.I. 34421).

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TWO NEW COMBINATIONS

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The following new combinations are proposed: *Nodulisporium verrucosum* (van Beyma) G. Smith and *Masoniella croci* (van Beyma) G. Smith.

Nodulisporium verrucosum (van Beyma) comb.nov. ≡ *Botrytis verrucosa* van Beyma, in *Verh. Akad. Wet., Amst. Afd. Natuurk.* (*Tw. Sect.*), **26**, 13, 1929.

Resulting from the publication of a description of *Nodulisporium africanum* G. Smith (*Trans. Brit. mycol. Soc.* **34**, 18, 1951), I received a letter from S. C. Damon, of the Philadelphia Quartermaster Depot Research Laboratories, pointing out that van Beyma's description of *Botrytis verrucosa* is very reminiscent of *Nodulisporium africanum*. The Centraalbureau voor Schimmelcultures Baarn very kindly supplied me with a subculture from van Beyma's isolate, and also another isolate labelled *Botrytis verrucosa* which had been received by the C.B.S. from Madame Nicot of Paris.

I have examined both cultures, and there is no doubt that van Beyma's isolate is a good *Nodulisporium*. It fits well with van Beyma's description, and resembles *N. africanum* in the formation of a black stromatic layer on the surface of the medium, in the general type of branching of the conidiophores, and in size of spores. The main difference between the two is in appearance of colonies. In *N. africanum* the aerial mycelium is dirty buff to brown and is markedly funiculose, whilst in *Botrytis verrucosa* it is floccose (not funiculose), almost white at first, then pale grey with a greenish tone and with some pinkish areas. The differences are sufficiently striking to justify, at any rate for the time being, the retention of the two specific epithets. However, it is possible that, when further isolates of similar morphology are available for study, the two isolates will have to be regarded as variants of a single species. In the meantime I propose, for the C.B.S. isolate, the name *Nodulisporium verrucosum* (van Beyma) G. Smith.

The Paris isolate, which also came to me as *Botrytis verrucosa*, is something quite different, neither *Botrytis* nor *Nodulisporium*, and is still under investigation.

Masoniella croci (van Beyma) comb.nov. ≡ *Scopulariopsis croci* van Beyma, in *Leeuwenhoek ned. Tijdschr.* **10**, 52, 1944.

Following on the distribution of cultures of *Masoniella grisea* and *M. chartarum*, I received from the C.B.S. Baarn, in December 1952, a culture of *Scopulariopsis croci* van Beyma, with a note to the effect that the Baarn workers did not consider it to be a typical *Scopulariopsis* but to be very similar to the two species of *Masoniella*. I have examined the isolate, which presumably represents van Beyma's type, and find good agreement with the latter's description. However, it is certainly not a *Scopulariopsis*, and I am in full accord with the Baarn workers in considering its proper place to be in *Masoniella*. It grows more quickly than either *M. grisea* or *M. chartarum* and eventually forms a more spreading colony. In addition, both the colony colour and the spores under the microscope are paler and distinctly browner in colour.

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SCLEROTINIA GLOBOSA IN BRITAIN

By JOHN WEBSTER
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(With 1 Text-figure)

Sclerotinia globosa Buchwald, the apothecial state of *Botrytis globosa* Raabe, is recorded for England and described.

Buchwald (1953) has described under the binomial *Botryotinia globosa* Buchwald, the apothecial state of *Botrytis globosa* Raabe previously reported by Webster & Jarvis (1951) parasitic on *Allium ursinum* from Britain. The perfect state has also recently been discovered in Britain, and the specimens match closely those described by Buchwald. The purpose of this paper is to place the British collections on record and briefly to describe them. The disease first appears among *A. ursinum* in the field towards the end of April as isolated infection foci. On a visit to Anston Stones Wood near Worksop on 20 April 1952 the ground beneath such localized infection foci was thoroughly searched, and by good fortune a single apothecium arising from an elongate black sclerotium was collected. Although visits were made within the following week further search proved fruitless. From the apothecium ascospores were shot off on to an agar plate. The ascospores germinated overnight, swelling and producing one or occasionally two germ tubes, 5–7 μ wide, 50–90 μ long, and branching at the tip within 16 hr. (Fig. 1 B). Nine single ascospore cultures were prepared on maize-extract agar and maintained at room temperature in diffuse light. Within 6 days the characteristic globose conidia were produced whilst numerous microconidia were also found in all cultures. The microconidia are produced from clusters of phialides borne directly on the prostrate hyphae or on short upright branches; they are globose and about 2 μ in diameter (Fig. 1 C). In older cultures they adhere in cream-coloured bead-like drops. Small sclerotia were also formed in the cultures on maize-extract agar within 11 days, especially in contact with the glass walls of the tube. Sclerotia were formed more readily on oat agar or on sterile wheat or barley grains in tap-water agar. Numerous attempts to produce apothecia by transferring microconidia to sclerotia have, so far, proved unsuccessful. Buchwald (1953) suggests that the fungus is homothallic.

In order to supplement the material, large numbers of sclerotia on dry withered leaves of *A. ursinum* were collected in July 1952, and placed on the surface of soil in pots. These were left to overwinter, and then transferred to a cool greenhouse in March 1953. Within a few days apothecia appeared at the soil surface, arising from the sclerotia. Their identity with *Botrytis globosa* was confirmed by means of cultures. The following description of the apothecia is based on both years' collections.

Sclerotia, black, 3–15 mm. long and 1–2 mm. wide when formed on the

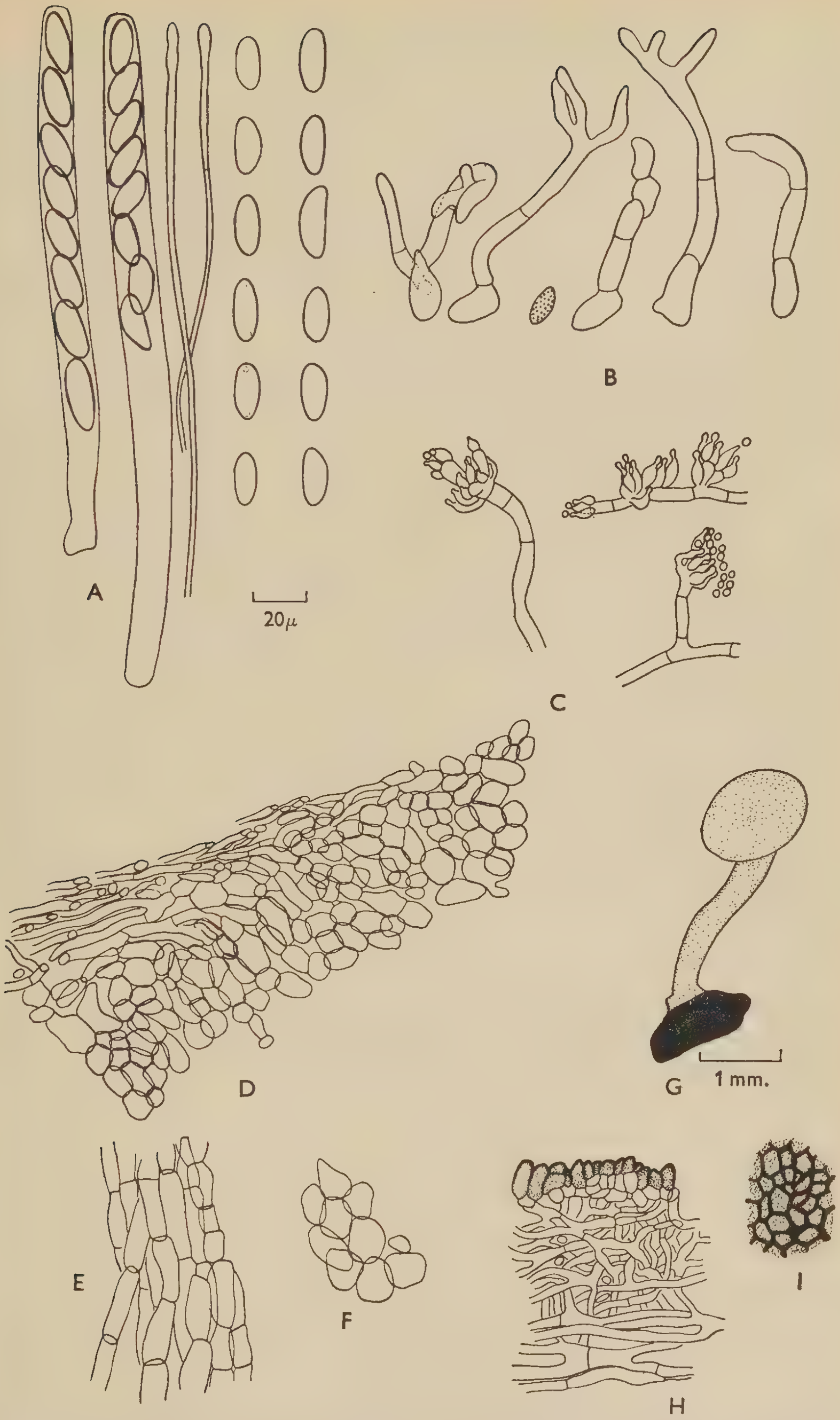

Fig. 1. *Sclerotinia globosa.* A, asci, paraphyses and ascospores; B, germinating ascospores after 16 hr. on maize-extract agar; C, phialides and microconidia from a 6-day culture; D, a portion of the apothecium and excipulum from a median longitudinal section; E, a portion of the stalk from the same section; F, surface view of excipulum; G, apothecium and sclerotium; H, a portion of a longitudinal section of a sclerotium; I, surface view of sclerotial cells.

midrib, or disk-like, 2–3 mm. in diameter when formed on the lamina; contents white, made up of interwoven thick-walled, branched septate hyphae, 2–4 μ wide, not embedded in a gelatinous matrix, but with interhyphal spaces; forming at the outside one or two layers of dark polygonal cells up to 10 μ wide (Fig. 1 H, I). The vascular tissues of the host leaf midrib are frequently distinguishable in the centre of the sclerotium.

Apothecia, 2–8 mm. high, stalked, the length of the stalk varying with the depth of the sclerotia beneath the soil surface, funnel-shaped, with a depression at the centre of the disk, finally becoming convex; disk 1·5–2·5 mm. in diameter. The surface of the stalk and lower surface of the cup are pruinose. The stalk is composed of files of cylindrical cells (Fig. 1 E) 6–12 μ in diameter. In the region of the expanded cup the files of cells are narrower, but turn outwards, widening to form an excipulum of inflated, thin-walled, rounded, yellowish cells, up to 18 μ in diameter, and occasionally projecting into short blunt processes (Fig. 1 D). The hymenium is composed of cylindrical asci with truncate tips, turning blue in iodine, 4- to 8-spored, 160–220 × 12–14 μ long, interspersed with paraphyses which slightly exceed the asci in length; they are about 2 μ wide for most of their length, but expand to 4–5 μ wide at the irregularly lobed tips (Fig. 1 A). The ascospores are uniseriate, elliptically inequilateral, smooth, hyaline, often with two small guttules; mature spores measure 18–27 × 9–11 μ (fifty measured in water).

The original British specimen (Mycological Herbarium of the University of Sheffield, No. 1124) has been deposited in the Herbarium, Royal Botanic Gardens, Kew. Cultures have been sent to the Centraalbureau voor Schimmelcultures, Baarn, Holland.

I gratefully acknowledge help from my wife in collecting sclerotia, and in searching for apothecia. I am also grateful to Dr R. W. G. Dennis for helpful advice.

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SOME PREDACIOUS FUNGI OCCURRING IN DUNG. II

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(With 3 Text-figures)

An account is given of some predacious fungi found in dung, two of them, namely, *Acaulopage lophospora* Drechsler and *Stylopage rhabdoides* Drechsler, being recorded for the first time in Europe.

Acaulopage lophospora Drechsler, *Mycologia*, **38**, 136, 1946

This fungus was obtained from dung collected from a dung heap at Great Kittle Farm, Bishopston, Glamorganshire, on 12 December 1952. Small pieces of this dung were placed on sterile maize-meal agar plates on 13 January 1953, and the fungus was first observed 8 days later.

The mycelium consisted of colourless, non-septate hyphae, 1·5–2 μ wide, capturing amoebae and absorbing their protoplasmic contents by means of rather bush-like haustoria (Fig. 1 *a*). Conidia were produced at the tips of prostrate hyphae (Fig. 1 *b*). The conidia were colourless, flask-shaped structures, with an empty basal stipe and six to twelve appendages at the distal end. The living cell measured 13–32 μ in length and 8–17 μ in greatest width. The empty stipe was 1·5–4·5 μ long and 1–2 μ wide. The appendages were filled with cytoplasm in the developing conidium but were empty in the mature conidium; they were 4·5–12 μ long and about 1·5 μ wide at the base (Fig. 1 *c*). Sexual reproduction was not observed.

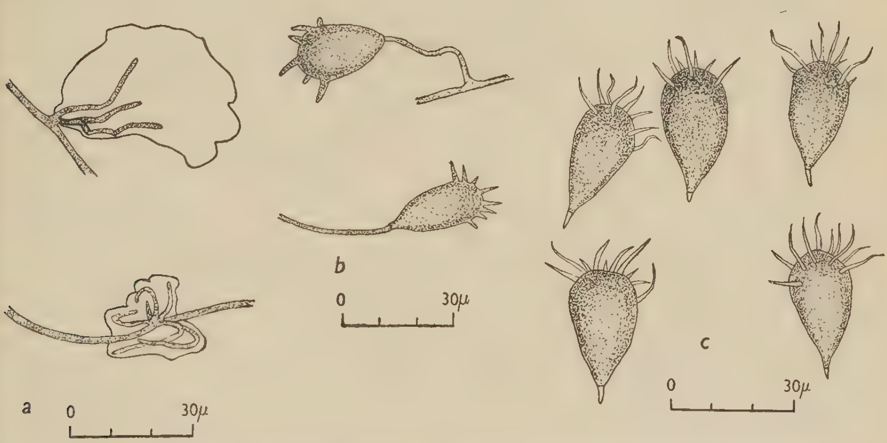

Fig. 1. *Acaulophage lophospora* Drechsler. *a*, haustoria inside captured amoebae; *b*, developing conidia; *c*, mature conidia.

The material that I had under examination agreed very well with that described by Drechsler (1946), although the living cell of the conidium had a greater range in size than in his account of the species.

Stylopage rhabdoides Drechsler, *Mycologia*, **39**, 262, 1947

Small pieces of cow (*Bos taurus* L.) dung, collected from the Open Spaces, Langdon Hills, Essex, on 27 April 1952 were placed on sterile maize-meal agar plates on 15 May. The fungus was first observed 12 days later growing out from the inoculum over the surface of the agar.

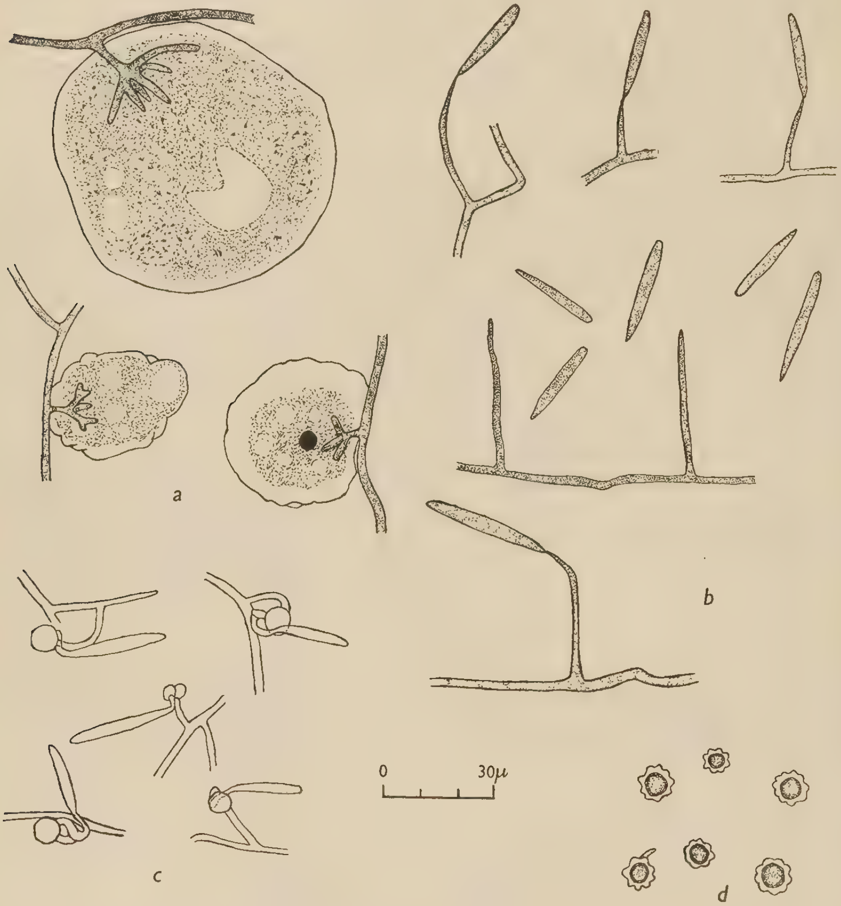

Fig. 2. *Stylopage rhabdoides* Drechsler. *a*, haustoria inside captured amoebae; *b*, conidiophores and conidia; *c*, development of zygosporangia; *d*, zygospores.

The mycelium consisted of colourless, branched, non-septate hyphae which were often vacuolate and had a diameter of 1·5–3 μ. The fungus captured amoebae, 35–75 μ in diameter, and absorbed their cytoplasmic contents by means of pedicellate haustoria (Fig. 2*a*). Arising from the prostrate hyphae were colourless, erect, simple conidiophores, each bearing a single terminal conidium. These conidiophores were 15–37 μ long and about 1·5 μ wide. The conidia were cylindrical, 20–35 μ long and 2–3 μ wide, pointed at the proximal end but rounded at the distal end (Fig. 2*b*). Sexual reproduction was first observed on 15 July; usually one of the zygophoric hyphae arose from the mycelium and the other from a germinating conidium (Fig. 2*c*). The zygospores were yellowish in colour, subspherical, with a thick, strongly warted wall; they were 8–10 μ in external diameter, the living cell being 5–6·5 μ in diameter (Fig. 2*d*).

Drechsler (1947) gives a conidial range of 25–57 × 2·7–3·5 μ for *Stylopage rhabdoides*, but apart from the somewhat smaller conidia, the fungus that I had under observation agrees very well with his description.

Protascus subuliformis Dangeard, *Botaniste*, **9**, 256, 1906

The genus *Protascus* was first described by Dangeard (1903). He gave a fuller account of this interesting endozoic fungus when he erected the species, *P. subuliformis*, in 1906. Dangeard did not observe sexual reproduction in the material that he was studying.

Maupas (1915) described a fungus which he called *P. subuliformis* Dangeard, but in his material the thallus was multi-septate and sexual reproduction was seen. Maire (1915) comments on this fungus:

> Maupas avait décrit celui-ci à cette epoque comme espèce nouvelle, mais son travail étant resté inédit, le champignon qu'il étudie doit garder le nom qui lui a été donné par Dangeard. Il y a toutefois quelques petites différences entre le parasite décrit par cet auteur et celui de Maupas. Le premier possède un thalle donnant naissance ordinairement à un seul sporocyste, rarement à deux, et peut-être parfois à plus de deux, ajoute l'auteur. De plus il ne présente pas de reproduction sexuée. Le seconde au contraire a un thalle donnant ordinairement plusieurs sporocystes et forme des œufs. Jusqu'à plus ample informé nous ne pensons pas qu'il y ait là deux espèces distinctes, mais seulement une race sexuée et une race asexuée du même parasite. La première, pourrait, si l'on veut, prendre le nom de *Protascus subuliformis* var. *maupasii*.

Duddington (1946) recorded *P. subuliformis* for the first time in Britain from an old manure heap. He has recorded it again (1951*a*) from partly decayed plant remains and has published a description (1950).

I have obtained this fungus from old manure from Nocton Fen, near Lincoln, collected on 26 February 1953, and inoculated on to sterile maize-meal agar plates on 3 March. The fungus was first seen destroying large numbers of nematodes on 20 March. In the material that I was studying the sporangia were 18–87 μ long and 7·5–13 μ wide (Fig. 3*a*, *b*), producing large numbers of non-motile spores which were discharged from the sporangium through an exit tube (Fig. 3*c*). The spores were club-shaped, straight or slightly curved, and measured 12–18 μ in length and 2·5–3·5 μ in greatest width (Fig. 3*d*). Sexual reproduction occurred by the conjugation of adjacent gametangia (Fig. 3*e*), but the thick-walled resting spores were not observed.

In the fungus described by Maupas the spores were 20–25 μ long, and in Duddington's material they were about 20 μ long (personal communication). Unfortunately Dangeard gave no spore measurements in his account and no indication of the scale of his illustrations, so that erection of a new variety on spore size alone does not seem desirable at the moment.

Arthrobotrys robusta Duddington, *Trans. Brit. mycol. Soc.* **34**, 598, 1951

This fungus was isolated from old farm-yard manure from a garden at Kittle, Bishopston, Glamorganshire, collected on 3 January 1953 and inoculated on to sterile maize-meal agar plates on 13 January. The fungus was first observed capturing nematodes by means of three-dimensional networks on 29 January. The fungus that I had under observation agreed very closely with that described by Duddington, but the conidia had a wider range, 13–33 μ long and 8–12 μ wide (Duddington, 18–27 × 8–12 μ). In pure culture on maize-meal agar they measured 12–22 × 4·5–10·5 μ (Duddington, 18–24 × 8–12 μ). In both cases the majority of the conidia were within the range given by Duddington (1951 *b*).

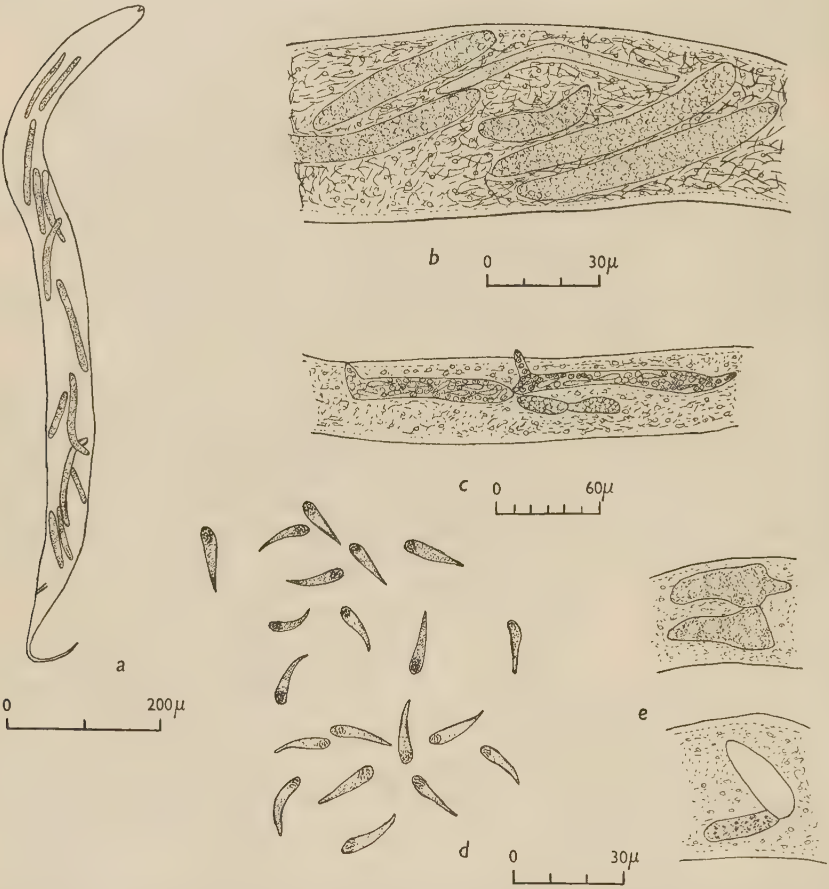

Fig. 3. *Protascus subuliformis* Dangeard. *a*, a nematode containing several sporangia; *b*, portion of a nematode containing young sporangia; *c*, portion of a nematode containing sporangia with exit tubes; *d*, spores; *e*, portions of a nematode containing conjugating gametangia.

All measurements and drawings used in this paper have been made from fresh material.

My thanks are due to Mr D. G. Twomey for providing the samples from which *Acaulopage lophospora* and *Arthrobotrys robusta* were recorded, and to Mr M. Brook for providing the sample in which *Protascus subuliformis* was found. I would also like to thank Dr C. L. Duddington for his continued help and guidance during the course of this work.

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(*Accepted for publication* 27 *July* 1953)

REVIEWS AND NOTICES

REVIEWS

Mushrooms and Toadstools. By JOHN RAMSBOTTOM. (London: Collins. 1953.) xiv + 306 pp., 70 plates (46 in colour). Price 30*s.*

Dr Ramsbottom's position in British mycology is unique. Forty years at the British Museum has seemed to have incorporated him into our mycological 'tradition', and there must be few working mycologists of to-day, whether professional or amateur, who have not at one time or another been as grateful to him for his advice and help as for access to the collections in his charge. In no branch of mycology has the influence of 'J.R.' been more felt than in our own Society in which he held office for nearly a quarter of a century and of which he was twice president. During the inter-war years no foray was complete without the General Secretary who would often arrive late at night, straight from South Kensington and with no hotel booked; while in the woods his civil-servant-like appearance (though far from civil-servant-like outlook) in his dark grey city clothes will long be remembered by both the tyro and the expert whose questions he answered with equal good humour. 'J.R.' was, however, in his element at the Museum, and to visit the General Secretary on Society business was never a matter that could be hurried. On arrival one picked a cautious way across the Keeper's room between the piles of books, specimens, and papers (and for the best part of a decade proofs of coloured plates of the book under review), which covered table, chairs and floor, to find 'J.R.' seated behind a barricade of correspondence at the desk that once belonged to Sir Joseph Banks. If the point of the visit was never reached it did not greatly matter for time passed pleasantly enough as some mycological rarity was displayed or some mycological anecdote recounted.

'J.R.' has always been busy (during his last years at the Museum very busy) and though his writings have been considerable they have often been tantalizingly brief. The quality and flavour of the much used British Museum Handbook, the Benn's Sixpenny introduction to mycology (a model of lucid popularization), his 1939 address to the Linnean Society which sets a standard for the mycological historian, the two King Penguins, and his presidential addresses to Section K of the British Association and other organizations have led his readers to hope that one day the essence of the author's vast store of mycological learning might be distilled in a more convenient form. This has now been done.

Mushrooms and Toadstools, like its author, is complex and erudite. Its flavour can perhaps be best indicated by a random sample, the opening chapter on Stinkhorns. This begins with a quotation from Tennyson. Extracts from seventeenth- and early nineteenth-century naturalists follow, and the page concludes with a footnote recording a curious observation by the famous French mycologist Bulliard. Overleaf, an original observation is recorded in true eighteenth-century style—'At Albury, Surrey, in 1932 I found five complete fruit-bodies with the bases of their stems enclosed in a single volva'—and then there is an outcrop of modern mycological terminology: 'The spores are borne on basidia within cavities of the reticulated pileus. The spore-bearing mass is known as a gleba....' There are two further chapters on Gasteromycetes, and among other topics dealt with at length are poisonous and edible fungi, mushroom growing, truffles, ergot, fairy rings, luminosity, history, habitats, dry rot, and penicillin. On every page of this mycologist's 'bedbook' there is something to stimulate the imagination or curiosity.

One of the features of the book which marks a more orthodox addition to the literature of British mycology is the lists of larger fungi associated with woodlands, grassland, and other habitats (including charcoal and burnt ground) but these sections appear to have suffered in making the book fit its covers. Many of the coloured plates are attractive. The half-tone illustrations are uniformly excellent.

G. C. AINSWORTH

Diseases of British Grasses and Herbage Legumes. By KATHLEEN SAMPSON and J. H. WESTERN. 2nd edition. (Cambridge University Press. 1954.) xiii + 118 pp., 59 figures. Price 15*s.*

To mycologists and others interested in the diseases of pasture and forage crops Miss Sampson and Dr Western's bulletin, *Diseases of British Grasses and Herbage Legumes*, published in 1941 quickly became an indispensable reference book; it not only fulfilled their aim to make available in a more accessible form the information, scattered in numerous periodicals, on the fungi that attack grasses and clovers of agricultural importance in Britain but it also filled a distinct gap in the plant pathological literature of this country. As might be expected the rapid advances made in the study of plant diseases since 1941 have contributed a considerable amount of new information on the diseases of these crops, and the authors are to be congratulated on having collected this together.

The pattern of the second edition follows closely that of the first. There are sections on all the diseases of grasses, turf and herbage legumes occurring in this country and a few, of particular interest not yet recorded here. For each of them, where appropriate, the symptoms produced, the diagnostic characters of the pathogen and the recommended control measures are described. There is also a section on mineral deficiencies. Additions have been made to nearly every section and some—for instance the section on Blind Seed Disease of ryegrass—have been expanded considerably. A number of new sections have been added including one on foot and root rots of grasses and several short ones on newly recorded diseases of lucerne and sainfoin. Much of the new information is taken from work done abroad and this is reflected in the additions to the bibliography which has been increased by nearly 200 references, only about a quarter of which are to publications by workers in the British Isles. The nomenclature of a number of the pathogens has been revised to bring it into line with current usage.

Several of the text-figures have been improved and a few new ones included. One new plate has been added, and it seems a pity that one or two more illustrations could not have been found to fill the blank page backing Plate 3.

There is little doubt that this new edition must replace the by now battered copies of the previous one on many plant pathologists' bookshelves and should also find a place on many others; it can be confidently recommended to anyone requiring a readable summary of the technical information on the subject. The production is a great improvement on the former edition and is worthy of its re-appearance in book form. The stiff covers will be particularly welcomed and the price is very reasonable.

The book is issued for the authors by the British Mycological Society, and the Royal Society made a grant towards the cost of publication.

F. JOAN MOORE

Manual of the North American Smut Fungi. By GEORGE WILLIAM FISCHER. (New York: The Ronald Press Company. 1953.) xii + 343 pp., 136 half-tone figures. $8.75.

Mycologists and plant pathologists both in and outside America will welcome a new handbook on the North American smut fungi. The earlier monograph by G. P. Clinton was published in 1904, revised in 1906 as part of the North American Flora series and amended by the *Additions and Corrections* of G. L. Zundel in 1939. These papers were not illustrated. Since then many new records of species, hosts and localities have been made. They have now been collected together, much of the material has been re-examined, fully described and photographed.

To say that the volume covers 22 genera, 276 species and several varieties of smut fungi on species of 242 host genera gives some idea of the scope of the book, though, as stated in the introduction, numbers depend upon the species concept of the author. As might be expected from his earlier publications, Prof. Fischer bases his concept of species on the morphology of sorus and spore, departing from this principle only where one or more species of smut, indistinguishable on spore characteristics, occur on hosts of different families. Thus *Urocystis agropyri* embraces the flag smut of grasses and wheat, but does not cover a similar *Urocystis* on *Colchicum*. Classifications and especially keys are man-made and it can certainly be argued that it is better to be conveniently inconsistent than inconveniently consistent.

As stated on the cover, the book is planned for maximum utility. To this end species are arranged alphabetically (irrespective of family since this involves the germination of spores) and a key combined with the host index provides in many cases a short cut to the identification of a species provided the host of the smut is accurately known. Other keys aid the diagnosis of species in the larger genera. The descriptions of the sori and spores are clear and concise, and the book is lavishly provided with excellent half-tone figures of the habit and spores, the latter magnified for the most part 900 times. The author and publishers are to be congratulated, not only on the number of the illustrations, but also on their clarity and artistic merit.

The absence of any notes on the germination and the behaviour of the fungus as a living organism will give many readers a sense of loss, but the author states that a later volume is planned dealing entirely with the biology of smut fungi. A reason for separating the material is not far to seek, since intensive work on biology has been conducted on comparatively few species, while in many others even the mode of germination of the spore is unknown. We shall look forward eagerly to the proposed book on biology as a companion to this attractive and very useful *Manual of the North American Smut Fungi*.

KATHLEEN SAMPSON

Monografia Uredinalelor din Republica Populară Română. By TRAIAN SĂVULESCU. (Academiei Republicii Populare Române. 1953.) 2 vols. xxiv + 1166 pp., 54 plates (6 coloured) + 948 text-figures, many tables. Price not marked.

These huge volumes (pages 11·3 × 8 in.) constitute an impressive monument to part of the work done by Săvulescu during the last twenty-five years, in which he published many papers and issued 1500 exsiccati of Roumanian fungi. The text is much like Latin, and the illustrations are excellent.

Vol. I deals with the morphology and biology of the rusts, with particular reference to those causing loss to economic plants in Roumania. A score of folding sheets of tabulations, each about a yard long, give the results of tests from 1936 to 1948 of 360 varieties of cereals for resistance or susceptibility to cereal rusts. Fifty pages of bibliography are given for this volume.

Vol. II (pp. 330–1166) gives citation, bibliography, synonymy, description, list of hosts and specimens, geographical distribution, and figures (a total of 883) for each of the 69 species of Melampsoraceae, 350 of Pucciniaceae, and 18 of unconnected *Aecidium* included. Roumania must be a country rich in species of rusts, but it is evident from this total of 437 species that the author is not a lumper. For example, he includes 14 species of *Puccinia* on *Carex*, distinguished primarily by the aecidial host, 13 of *Coleosporium*, and 26 of *Melampsora*. All this is, however, the uredinology still commonly followed; the alternative procedure of grouping species into synonyms, forms, or varieties needs to be standardized. Nor can one blame the author for not accepting the 1950 Rule that a name based only on *Uredo* is invalid for transfer as the name for the perfect state, since that Rule makes many names uncertain.

This work is valuable not only to Roumanians, but to all uredinologists as a thorough and well-illustrated survey of European Uredinales. G. R. BISBY

Flora of Bedfordshire. By JOHN G. DONEY. (Luton: The Corporation of Luton Museum and Art Gallery. 1953.) 532 pp., 1 map, 22 text-figures, 25 plates. Price 42*s*.

This volume, handsomely produced by the Luton Museum, is basically an up-to-date county flora on more or less conventional lines. Ecology is emphasized in an unconventional but welcome feature—a series of nearly 100 'habitat studies' in areas of 5 yards radius chosen as representative of the vegetation typical of the county. Each area has been surveyed by Dr Doney at least once in spring, summer and autumn, and many of them are illustrated by photographs. A grant from the Royal Society has made it possible to devote over 30 pages to records of fungi, compiled by Mr Derek A. Read, who has himself collected extensively in the county. P. H. G.

Bibliographie der Pflanzenschutzliteratur, 1940–1945. By J. BÄRNER. (Berlin: Biologische Zentralanstalt für Land- und Forstwirtschaft. 1953.) Vols. I and II, xlviii + 1308 pp. Price D.M.W. 97.0.

Between the two world wars the Biologische Reichanstalt (later the Zentralanstalt) at Berlin-Dahlem produced twenty volumes of the *Bibliography of Plant Protection*, covering the literature from 1914 onwards. The United States European Recovery Programme has now provided funds for its continuation and these volumes are valuable in giving titles and references to plant pathological literature of all countries during the period when the world was divided by war. Entries are arranged alphabetically under authors within a broad subject index. Nearly 50 pages are given to general mycology, pathogenic fungi and taxonomy. The main part of the bibliography is classified under crop plants and there are sections on fungus diseases under each host. P. H. G.

NOTICES

A Dictionary of the Fungi. By G. C. AINSWORTH and G. R. BISBY. 4th revised edition. (Kew: Commonwealth Mycological Institute. 1954.) viii + 475 pp. Price 20*s*.

An Introduction to the Taxonomy and Nomenclature of Fungi. By G. R. BISBY. 2nd revised edition. (Kew: Commonwealth Mycological Institute. 1953.) vii + 143 pp. Price 10*s*.

The most important addition to this useful little book, which reprints and annotates for mycologists the latest *International Code of Botanical Nomenclature*, is a series of short sections giving the main features of the major groups of fungi.

British Species of Periconia. By E. W. MASON and M. B. ELLIS. Mycological Papers, No. 56. (Kew: Commonwealth Mycological Institute. 1953.) 127 pp., 4 plates, 43 text-figures. Price 30*s*.

The 15 British species are described, figured and keyed out against a detailed historical background.

British Hypogeous Fungi. By LILIAN E. HAWKER. *Phil. Trans.* B, no. 650. (Vol. **237**, pp. 429–546.) (London: Cambridge University Press. 1954.) Price 27*s*.

This comprehensive monograph gives keys and descriptions for the 22 genera and 67 species of hypogeous fungi belonging to the Phycomycetes, Ascomycetes and Basidiomycetes which have been recorded for Great Britain and Northern Ireland.

Les Agaricales de l'Île de la Trinité: Rhodosporae-Ochrosporae. By R. G. W. DENNIS, *Bull. Soc. mycol. Fr.* **69**, 145–198. 3 colour plates, 9 text-figs., 1953.

This account of the Rhodosporae and Ochrosporae of Trinidad includes descriptions of 11 new species (9 of *Entoloma*) and 3 new varieties. (For an account of the Leucosporae, see *Trans. Brit. mycol. Soc.* **34**, 411–482, 1951.)

PROCEEDINGS, 1953

MEETINGS

Meeting held at the London School of Hygiene and Tropical Medicine, London, W.C. 1, at 11.0 a.m., 17 January 1953. The President, Prof. C. T. Ingold, in the Chair.

W. G. Keyworth. Studies on the physiology of parasitism of wilt fungi.
C. T. Ingold. The form of ascospores.
H. J. Brodie. Splash dispersal and culture studies in the Nidulariaceae.
J. M. Hirst and P. H. Gregory. Short period changes in the air spora, with particular reference to basidiospore content.

Meeting held at Birkbeck College, London, W.C. 1, at 11.0 a.m., 13 March 1953. The President, Prof. C. T. Ingold, in the Chair.

E. W. Buxton. *Fusarium oxysporum* and the Gladiolus.
J. S. Waid. Observations on the fungi associated with the roots of beech seedlings.
N. F. Robertson. The biology of pine mycorrhiza.
C. G. C. Chesters and A. Apinis. Certain thermophilic soil fungi.
H. Stenton. The soil fungi of Wicken Fen.
S. D. Garrett, F. C. Butler and B. L. Lucas. Problems of saprophytic behaviour of root infecting fungi.

Meeting held at Birkbeck College, London, W.C. 1, at 11.0 a.m., 16 October 1953. Dr C. J. Hickman in the Chair.

K. Mather. Variation in wild populations of fungi.
E. W. Buxton. Variation in *Fusaria* from prematurely yellowed *Gladiolus*.
P. R. Day. Physiologic specialization in *Cladosporium fulvum*.
H. W. Howard. Breeding potatoes for resistance to Late Blight and other diseases.
R. D. Reid. Red Core Root Rot of strawberries: Some experiences in breeding for resistance.
(See *Nature*, **172**, 989, 1953.)

ANNUAL GENERAL MEETING, 1953

The fifty-seventh Annual General Meeting was held in the rooms of the Linnean Society of London, at 12 noon on Saturday, 12 December 1953, with President, Prof. C. T. Ingold, in the Chair.

After the minutes of the previous Annual General Meeting had been read and signed, the President recorded with regret the death of Mrs Montague, a foundation member, and Dr A. R. Dillon-Weston. He then briefly reviewed the year's activities.

The Treasurer presented his annual statement which was accepted *nem. con.*

The following resolutions were adopted:

1. That Rule 2 shall be amended to read '...the number of Honorary Members shall be limited to 12 at any one time'.

2. That Rule 4 shall be amended to read 'The Officers of the Society shall consist of a President, two or more Vice-Presidents, Treasurer, Secretary, Foray Secretary, Secretary of the Plant Pathology Committee and Editor or Editors....'

3. Addition to Rule 9. 'Members of at least 25 years' standing who are over 65 years old (or over 60 if already in retirement) may pay a subscription at half the normal rate, if they have not signed a Covenant, or when their Covenant expires.'

The following Officers and Council for 1954 were then elected: *President*: S. D. Garrett; *Vice-Presidents*: W. D. Graddon and the two past Presidents, A. A. Pearson and C. T. Ingold; *Secretary*: J. Webster; *Foray Secretary*: F. B. Hora; *Plant Pathology Secretary*: C. C. V. Batts; *Treasurer*: W. Buddin; *Editors*: P. H. Gregory and G. C. Ainsworth; *Members of Council* (to replace C. C. V. Batts, P. D. Orton, I. F. Storey): J. Colhoun, J. G. Manners, B. E. Plunkett. H. F. Dovaston, J. M. Hirst, and R. A. Lelliott were elected members of the Plant Pathology Comittee (to replace Dr Mary Noble, E. C. Large, P. H. Williams). D. A. Reid was elected to the Foray Committee. Nine new members and three associates were then elected, making a total of thirty-five new members and seven new associates for the year. A brief discussion of the 1954 programme then followed.

In the afternoon the President gave his address 'Fungi and Water'. The meeting concluded with a vote of thanks to the President for his services to the Society.

RECEIPTS AND PAYMENTS for the year ended 30 June 1953

	£	s.	d.	£	s.	d.
1 July 1952, Balance brought forward ...				711	5	6
Cambridge University Press, Sales:						
Transactions, Vol. 35	825	1	0			
Reprints	110	11	9			
Back Volumes	444	3	1			
50-Year Index	139	11	11			
Miscellaneous	9	19	4			
Advertisements	1	17	10			
List of Common Br. Pl. Diseases	5	8	0			
				1536	12	11
Diseases of British Grasses				1	14	7
Sundry Sales at Meetings, etc.				30	6	8
Subscriptions:						
Arrears	4	0	0			
Current	735	2	1			
In advance	25	10	9			
Associates	14	5	0			
Income Tax Repayment	94	0	7			
				872	18	5
Donations:						
Cheesman and Pethybridge Funds... ...	3	10	0			
For Plates (Vols. 34 and 35)	157	6	3			
For General Printing Fund	117	13	10			
				278	10	1
1952 Grant through Royal Society ...				400	0	0
Interest:						
Capital Reserve Fund	27	17	6			
Post Office Savings Bank	6	7	3			
				34	4	9
				£3865	12	11

	£	s.	d.	£	s.	d.
Cambridge University Press:						
Production, *Transactions*, Vol. 35 (1100 copies)	1089	15	7			
Reprints	183	9	9			
Advertisements	5	2	0			
Distribution of Members' copies, Vol. 35	58	2	0			
Transactions bought in	8	10	0			
Commissions on:						
Production Vol. 35 and Reprints ...	160	17	2			
Sales of Vols. 1–35	140	10	10			
Sales of 50-Year Index	34	18	0			
				1681	5	4
Subscriptions:						
Woolhope Club	1	0	0			
British Co-ordinating Committee for Nature Conservation	2	0	0			
Biological Council	1	10	0			
				4	10	0
Postages, Stationery, etc.				57	10	10
Sundry Printing				54	14	6
Hospitality Fund				0	18	10
Purchases—Library and Back *Transactions* ...				3	17	2
Fees for Meetings				3	12	0
Balance:*						
At Midland Bank	1034	19	7			
In Post Office Savings Bank	1024	4	8			
				2059	4	3
				£3865	12	11

* The Society is committed to the production of new editions of Sampson & Western's *Diseases of British Grasses*, and of the *List of Common Br. Pl. Diseases*.

Donations from numerous members to the several Funds of the Society are gratefully acknowledged.

CAPITAL RESERVE FUND (Nominal values of Stock).

Cheesman and Pethybridge Funds...	£260 of 3½% War Stock	General Hospitality, Library and Printing Funds	£365 of 3½% War Stock £375 of Savings Certificates £200 of 3% Defence Bonds†
Lister Fund	£300 of Savings Certificates		
			GRAND TOTAL £1500

† Converted on 1 July 1953, to £200 of 3½% Defence Bonds.

THE SPRING FORAY

JUNIPER HALL, 29 May to 1 June 1953

By F. B. HORA, *Foray Secretary*

The twenty-fourth Spring Foray was held near Dorking, Surrey, from 29 May to 1 June. The 24 members who attended were all accommodated at the Juniper Hall Field Centre where the Warden, Mr G. E. Hutchings, Mrs Hutchings and the Secretary, Miss A. Dunn, made our stay very comfortable and were most helpful. This Centre is situated in a chalky area in the valley of the Mole and offers many different ecological habitats: there is even a well-developed heath flora on Juniper Top (on the way up, the Roman Snail can be gathered in abundance). About a mile from the Centre, in a southerly direction is Box Hill, one of the best known summits of the North Downs, rising 600 ft. above sea-level and with a most impressive south-facing escarpment. Although freely open to the public, Box Hill still offers an excellent introduction to Chalk Flora (see J. E. Lousley, *Wild Flowers of Chalk and Limestone*, 1950). Although the season was too early for most of the wild flowers, we were fortunate in seeing the rare and beautiful *Ajuga chamaepitys*.

For many aspects of the History and Natural History of the area, *The Book of Box Hill* by Mr G. E. Hutchings makes delightful reading.

Mycological collecting areas visited were Juniper Hill, Juniper Top and Juniper Bottom, Box Hill, White Hill and Norbury Park. All these areas and many others in the neighbourhood are first class for the collecting of toadstools, whilst the Field Centre offers all the necessary opportunities for their serious study with a microscope.

In considering our Spring Foray collecting, it must be remembered that the relative number of species named is more a reflexion of the interests of those members present than of the current state of the fungus flora. Some figures for species named in the different groups are: Agarics (26), Polypores (9), Rusts (32), Smuts (4); other micro-fungi (24). The Agarics included one new British record *Coprinus auricomus* Pat., macroscopically very similar to *C. plicatilis* for which it was at first mistaken. *C. auricomus* may be known from *C. plicatilis* in the field by the gills not being separated from the stem apex by a distinct collar. Microscopically, the cap, especially the disk, is beset with very striking long, yellowish brown, thick-walled setulae which are absent from *C. plicatilis*. The spores are also different. The characteristic spring species *Nolanea hirtipes* was so named, but subsequent examination showed lanceolate acuminate cystidia on the gill edge, whereas that species has cylindric sub-capitate ones. So far it has not been possible to name our find.

A second new record to the British Isles, and one which caused considerable excitement, was a Smut on *Brachypodium*. Hitherto, no Smut has been recorded in this country on that grass. It was finally identified by Dr Joan Moore as *Tilletia olida* (Riess) Wint., now known as *Ustilago olida* (Riess) Cifferi (specimens in: Herb. Path. Lab. Harpenden; Herb. Univ. Coll. Exeter). It is recorded from France, Germany, Austria, Italy, Switzerland and Spain and always on *Brachypodium* species.

No further outstanding finds occurred. Full lists of all species named will be gladly sent to anyone who makes application to me.

THE DUNKELD FORAY, SCOTLAND

1–8 September 1953

By F. B. HORA, *Foray Secretary*

In choosing Dunkeld, Perthshire, for the 49th Autumn Foray, the Society was breaking new ground. With one exception, the experiment was an unqualified success. Fungi were in abundance, accommodation was to everyone's satisfaction, and full facilities for serious work were available to all. The one exception was that Mr Pearson was unable to be with us on account of illness.

About fifty members attended the Foray and were accommodated at Dunkeld or at Birnam, about a mile away across the river. Birnam Institute was put at our disposal as a laboratory and for meetings.

The local arrangements were made by Mr D. M. Henderson of the Royal Botanic Garden, Edinburgh, and we are all indeed deeply grateful to him for his hard work on our behalf.

As our foreign guest, we were particularly fortunate in having with us the distinguished Danish plant pathologist, Prof. N. F. Buchwald of the Royal Agricultural and Veterinary College, Copenhagen. Both his wide and specialized knowledge were always at our disposal. He charmed us with his ready wit and the zest with which he entered into the spirit of an Autumn Foray.

It was a pleasure to give an interview to a representative of the local Press and a statement about our activities appeared in the *Perthshire Advertiser* for 12 September 1953. It is appropriate to quote a short paragraph. 'For many of the Society's members it was their first visit to Scotland and all are returning with the most pleasant memories of the warm hospitality of its people and of a magnificent countryside seen under ideal conditions.' The weather was, indeed, kind to us. Up to the time of our arrival it had been raining heavily and continuously; but then it stopped and we were only once inconvenienced by it.

As has become our custom, excursions were arranged so as to alternate a full day's collecting with a half-day's collecting, thus giving time for working over material. The first half-day was to Stormont Loch, Blairgowrie (*S.*). (Letters in brackets indicate abbreviations used for localities in this report.) Next day (Thursday), after a 45 mile journey, saw us at the Black Wood of Rannoch (*R.*) a fine example of relic Scots Pine. Friday was spent on the local Tay banks (*T.*). Saturday was set aside as a free day and a trip was organized, as our President put it 'to the region of Ben Lawers' (only a small party led by the President got to the top). All Sunday was spent on the Murthly Castle Estate (*M.*) and on the Monday afternoon we visited the Craiglush Loch plantation (*C.*).

In reporting on the collections, bare lists have been avoided in favour of drawing attention to what seem to be the more interesting finds. It is emphasized, however, that the full lists of all species named (including localities) will be sent to anyone on application to the Foray Secretary.

AGARICALES

Nomenclature follows the 'Revised List of British Agarics and Boleti' by Pearson & Dennis (*Trans. Brit. mycol. Soc.* 31, 145–190, 1948). Names not in that list are given author citation according to Konrad & Maublanc, *Les Agaricales*, 1948, 1952.

In all, nearly 300 species were collected. Several gatherings of *Lepiota metulaespora* (B. & Br.) Sacc. sensu Bresadola were made (*M.*). This is a good species, distinct from *L. clypeolaria* to which it has been formerly referred. In *Tricholoma*, *T. atrocinereum* (*M.*) was of interest as being one of a very small number of species of that genus having a cellular (hymeniform) cuticle (section *Dermoloma*). Fine specimens of *Tricholoma decorum* (*R.*) were seen. It is related to *T. rutilans* but is wholly yellow and is one of those species which seem to affect northern latitudes or mountains and this may account for its uncommonness. The tufted *Clitocybe connata* (*M.*) should be mentioned if only to recall that it is one of a very few species whose basidia react anomalously towards aceto-carmine. Carminophil granules are present in young basidia but not in old. The normal reaction is that such granules are either constantly present or constantly absent. Particularly interesting finds were those of *Mycena pseudo-pura* Kühner (non Cooke) (*M.*). This species has probably in the past been mistaken for a small form of *M. pura*, but it is quite distinct. As interpreted by Kühner, the spores are non-amyloid. Pearson (*Trans. Brit. mycol. Soc.* 35, 104, 1952) points out that Cooke's type specimens in the Kew herbarium have amyloid spores, so a new name will have eventually to be found for the Kühnerian interpretation. Amongst critical species of *Collybia*, there was *C. clusilis* (*M.*) (*Omphalia clusiformis* Kühn & Romagn.) and there were two interesting members of the section *Tephrophanae*, *Collybia ambusta* (auct. pl.) (*T.*) (*Lyophyllum sphaerospora* Kühn. & Romagn.) and *Collybia erosa* Fr. sensu Lange (locality not known) (*Lyophyllum plexipes* (Fr.) Kühn. & Romagn.). The bracketed synonyms are taken from the recently published Flora by Kühner & Romagnesi. *Marasmius cauticinalis* is another of those species which is not often encountered, because it seems to require either mountains or northern latitudes. Very fine specimens were seen. Nomenclatural troubles may eventually require it to be re-named *M. fulvo-bulbillosus* Rob. Fries. Under the name *M. acervatus*, Jules Favre has recently shown that two distinct species are involved. *M. acervatus* should be retained in the sense of Karsten for the much less common of the two, and specimens agreeing with this interpretation were found at Rannoch. For the quite common species to which it has been the custom to give that binomial, Kühner and Romagnesi suggest the new name *M. bresadolae*. A new record for the British Isles was found in *Omphalia bi-sphaerigea* Lange (locality not recorded). *O. asterospora* Lange (*M.*), gathered for the first time in a previous year, was also taken. Good examples of the yellow-capped *O. postii* were seen in its usual habitat of boggy places with *Sphagnum*. In *Pleurotus porrigens* (*R.*) there was found still another of those species characteristic of northern latitudes or mountain regions. It was pleasant to see *Nyctalis parasitica* (*M.*) as a change from the more common (at least in the south) *N. asterophora*. It may be noted in passing that this genus has also been found to possess carminophilous granules in its basidia. *Hygrophorus eburneus* (*M.*) is mentioned because some of the gatherings may have included another and very similar beech-wood species *H. chrysaspis* Métrod. The points of distinction were not fully appreciated at the Foray. Other species were *H. pustulatus* (*M.*, *C.*), under fir trees, and *H. laetus* (*R.*). More than two dozen species of *Lactarius* were named, but the most outstanding was without doubt *L. representaneus* (*R.*) (see Pearson, *Trans. Brit. mycol. Soc.* 32, 258, 1948). This is allied to *L. scrobiculatus* (*R.*) which was also seen. Mention may be made of *L. uvidus* (*R.*) and certain gatherings referred to as *L. trivialis* (*R.*) Of the latter some were undoubtedly that species, but others were puzzling. Confusion is easy with *L. glutino-pallens* Moeller & Lange, which is not well-known in this country, and even Lange's own forma *constans* of *L. vietus* is agreed by French mycologists to be *L. trivialis*! It was at such times, and they were not few, that the absence of Mr Pearson was most felt. Opportunity was afforded for getting better acquainted with such troublesome species as *L. decipiens* (*R.*, *M.*) (see Pearson, *Trans. Brit. mycol. Soc.* 35, 108, 1952), *L. obscuratus* (*C.*), *L. subdulcis* (*R.*, *M.*, *T.*) and *L. tabidus* (*M.*). The last named is now clearly defined and is a good British species. Another mountains or northern latitudes species was *Cantharellus lutescens* (*R.*), not to be confused with *C. tubaeformis* var. *lutescens* Fr. Finally, amongst white-spored toadstools was *Plicatura crispa* (*M.*).

Relatively few pink-spored agarics were named or collected. *Leptonia asprella* (*C.*) and *L. formosa* (*S.*) are worthy of mention, so also is *L. chalybea* (*R.*, *M.*) if only for the beauty of its deep blue-violaceous-black colour. *Nolanea juncea sensu* Lange (*M.*, *C.*) was also named.

Coming now to brown-spored species, fine tufts of *Pholiota flammans* (*R.*) were gathered from coniferous stumps. A passing reference is made to our commonest *Flammula* as a reminder that in future it may have to be known as *F. penetrans* rather than *F. sapinea* (*T.*, *M.*, *R.*, *C.*). *Galera tibiicystis* Atkinson (*R.*) was a good find, but has perhaps, in the past, been confused with *G. sphagnorum* (see Pearson, *Trans. Brit. mycol. Soc.* 35, 113, 1952). Mr Peter Orton is especially interested in the difficult genus *Cortinarius*, and he was able to identify some thirty species from the material collected. In the section *Myxacium*, there was *Cortinarius delibutus* (*S.*), *C. elatior* (*R.*, *M.*), and *C. vibratilis* (*R.*). *C. triumphans* (*R.*, *C.*) was the sole representative of the section *Phlegmacium*. Other species were *Cortinarius callisteus* (*R.*), *C. bivelus* (*C.*), *C. gentilis* (*R.*), *C. helvolus* sensu Bresadola (*C.*), *C. phoeniceus* (*R.*), commonly confused with the *C. semi-sanguineus* group, *C. rubricosus* (*C.*), *C. tabularis* (*C.*) and *C. traganus* (*R.*). Kühner's recently described *C. parvannulatus* (*C.*) was also named by Mr Orton and constitutes another new British record. *The* genus *Inocybe* was poorly represented in our lists. Perhaps *I. mixtilis* (*M.*) a close ally of *I. praetervisa*, should be noted.

Very little need be said of the purple-spored species. *Hypholoma pyrotrichum* (*M.*) occurred and also what appeared to be *H. epixanthum* (*M.*). The latter specimens were not 'rooting', nor does Fries make any mention of a 'root'. As interpreted by Ricken and Lange (who renamed it *H. radicosum* because of the confused synonymy), the presence of a 'root' is definitely indicated.

Nothing of interest among black-spored species was named. A number of different species of the difficult genus *Psathyrella* were collected, but only two common ones identified.

In the Boletales, *Boletus flavidus* (*R.*) was a splendid find—another northern or mountains species. A real joy was the finding of both species of the genus *Gyroporus*, *G. castaneus* (*T.*) and *G. cyanescens* (*R.*).

Taken as a whole the agarics and boleti were very well represented, the Black Wood of Rannoch and the Murthly Castle Estate being particularly productive.

APHYLLOPHORALES

About fifty species of the Aphyllophorales were named. In the Hydnaceae, we were fortunate to find the often elusive *Hydnum fragile* (*R.*). Mr Derek Reid has kindly supplied me with the following information about polypores. Few interesting species were found, but two deserve special mention. These are *Lenzites sepiaria* (Wulf.) Fr. and *Fomes fomentarius* (L.) Kick. The former has a predominantly northern distribution in this country and occurs only on coniferous wood. It is not infrequent in Scotland and indeed those present were able to see good material at Rannoch and those that climbed to the top of Birnam Hill could see abundant growth of this fungus on the pine stumps still lying about as evidence of the great gales earlier in the year. It is easily recognized by its dark brown hispid surface which contrasted with the bright orange or rusty coloured margin. *F. fomentarius*, likewise, has an odd distribution in this country, and there are very few authentic records of its occurrence outside Scotland, despite the fact that it is common in most continental countries. It has in the past been confused with *Ganoderma applanatum* (Pers.) Pat., and so it was all the more valuable for members of the Society living in the south to be able to see it in such abundance, and so become familiar with it in all its forms. Its more distinctly ungulate shape, its milky coloured crust (changing to black in old specimens) and colour of its flesh serve to distinguish it macroscopically, whilst the spores are quite different from those of *G. applanatum*. It is usually found as a parasite on birch—sometimes growing together with *Polyporus betulinus* (Bull.) Fr., but it has been recorded from many other deciduous trees. *Polyporus rutilans* (Pers.) Fr. (= *P. nidulans* Fr.) was another species which is rarely collected. This was found on *Salix* sp., but it occurs on many deciduous trees. It was demonstrated how the flesh of this species gave a violet coloration with alkalis and a red solution when placed in alcohol. *Polyporus schweinitzii* Fr. was collected in abundance in most of the coniferous woods that were visited, and at Murthly Estate, many sterile juvenile forms were found. *Lenzites abietina* (Bull.) Fr. was also recorded but probably in error for *L. sepiaria*. Likewise *Polyporus albidus* is reported, but it is an open question as to what this refers.

GASTEROMYCETES

The only outstanding find in the Gasteromycetes was *Nidularia pisiformis*. It seemed that this group was generally not well represented.

UREDINALES

In the Uredinales, Dr Manners recorded some forty species. These included fine aecidia of *Chrysomyxa rhododendri* on *Picea excelsa*. This rust, known in Scotland since 1913, does not occur in England. Several other species uncommon further south were in abundance. These included *Puccinia lychnidearum* on both *Stellaria media* and *Moehringia trinervia*, *Puccinia gallii* on *Gallium uliginosum* and *Puccinia andersoni* on *Carduus heterophyllus*. Aecidia of *Gymnosporangium juniperinum* were abundant and striking on *Sorbus aucuparia*.

ASCOMYCETES

In the Ascomycetes there was little of interest to report in the Pyrenomycetes, although *Cordyceps ophioglossoides* made a fine sight in the Black Wood of Rannoch. When we consider the Discomycetes, however, the story is very different. Mr Graddon speaking of the season as a whole described it as 'wonderful—even overpowering'. I remember him telling me in mid-December that he was 'praying for frost', so great was the amount of material still coming in, owing to the prolonged mild autumn. His report of the Dunkeld gatherings of Discomycetes is as follows. Some seventy species were brought in and many were of considerable interest. At Stormont Loch a good start was made with several *Dasyscypha* species on leaves and culms of *Carex* and *Juncus*; dead branches of *Salix* gave *Lecanidion atratum* and an *Orbilia* which well matched the description of *O. alni* Vel. In the Black Wood of Rannoch were found superb colonies of the green-edged apothecia of *Lophodermium melaleucum* var. *pulchella* Fr. on dead leaves of *Vaccinium vitis-idaea*; *Galactinia badia* was plentiful in the mossy paths and *Ascocorticium anomalum* was taken on bark of Scots pine. In the grounds of Dunkeld House a fine colony of *Spathularia flavida* delighted us and an area of open ground under scattered beeches was particularly rich in species—*Lachnea hemispherica* and *Calycella citrina* predominating. The high spot of the week was reached on the Murthly Estate from which we emerged exhausted by abundant collecting in summer weather. Our picnic lunch was taken on Tay bank in company with several fine groups of *Otidea onotica* up to 4 inches high and *O. leporina* grew close by. Bonfire sites gave many species including fine *Aleuria lilacina*, *Tricharia gilva* and *Trichophaea albo-spadicea*. In a mossy path we found abundant apothecia agreeing well with *Pustularia gaillardiana* Boud. *Helvella crispa* and *H. lacunosa* were seen in several places and *Rutstroemia firma* and *Bulgariella pulla* were found on wood. Dead stems of *Angelica* had fine colonies of ascigerous *Heterosphaeria patella*. An exciting and rewarding day! On the final day, the President was at last able to enjoy an underwater hunt at Craiglush Loch and took several species including *Belonopsis excelsior* and a *Mollisia* probably as yet undescribed.

PHYCOMYCETES

Very few species of Phycomycetes were named and none was singled out as being worthy of special mention.

FUNGI IMPERFECTI

Many Fungi Imperfecti were collected, and a proportion of critical species have still to be worked out. In a preliminary list, kindly sent to me by Mr M. B. Ellis, the following were selected as of interest. *Clasterosporium vermiculatum* Cooke was found on rotten wood of beech. This is apparently only the second time it has been recorded since first described in 1875. *Gonytrichum macrocladum* (Sacc.) Hughes on rotten wood of oak was only its second time of being recorded in Britain; and it would seem that *Septotrullula bacilligera* v. Höhnel var. *cambrica* Grove & Rhodes, has been only recorded once before, from the type locality. It must have been extremely gratifying to the President that an examination of submerged leaves in Inchewan Burn, Birnam, yielded no less than eight of his own recently described aquatic Hyphomycetes.

MYXOMYCETES

Mr Howard, reporting on the Slime fungi, said that weather conditions for their development were very good, but various other factors seemed often to be against the appearance of any abundance of material. Thus the large area covered by the Black Wood of Rannoch yielded few species probably, thinks Mr Howard, because of the 'lack of dead wood due to the way in which the woods were so well looked after from a forestry point of view'. His best find there was *Cribraria rufa* Rost. on old pine boards by the saw mill. The Murthly Estate was the most productive because of the many heaps of decaying oak branches, most of which bore species characteristic of that habitat. From all the material brought in, there was one species which Mr Howard had not seen during many years work in his own (Norfolk) area. This was *Didymium crustaceum* Fries.

It only remains for me to express my thanks to all those members who have given me so much help in the preparation of this report. In addition to those already mentioned, I would like to add Miss Margaret Holden, who did splendid work in preparing the toadstool list. In the field, too, her keen eye and knowledge can always be relied upon to produce something of interest. Whilst working on this report, I received full lists of the personal collections of Prof. Buchwald. These cover all groups of fungi and give some idea of the wide range of knowledge of this eminent Danish mycologist. The lists were most helpful to me. Finally, I would like to thank Mr John Brooke for his help at all stages of the Foray.

LONDON, HOME COUNTIES AND PROVINCIAL DAY FORAYS

September and October 1953

In the London and Home Counties area, Day Forays were held at Cuffley Great Wood, Herts (a joint Foray with the Hertfordshire Natural History Society and Field Club); Juniper Hall, near Dorking, Surrey; Burnham Beeches, Bucks (joint Foray with the Middle Thames Natural History Society); Oxshot, Surrey; Virginia Water, Surrey; Ruislip Woods, Middlesex; and finally Windsor Forest, Berks (a second joint Foray with the Middle Thames Natural History Society).

These Day Forays confirmed for the south the definite impression gained from the Scottish Autumn Foray that 1953 has been a particularly fine year for toadstools.

Mycena maculata Karst., found for the first time in this country in Windsor Forest in 1952, was refound. This species is peculiar, at least among *Mycena*, in that the gills on being soaked in a strong solution of picric acid for several days, turn to a striking orange colour on subsequent rinsing in faintly alkaline water—hard tap water is sufficient. Windsor Park also yielded another new British record: Lange's *Psathyra* (*Psathyrella*) *stipatissima*. It is probable that this may prove to be the same thing as *P. multipedata* Peck, first described from America.

The Provincial Day Forays were all joint Forays with local Natural History Societies. Areas visited were Great Wood, Broadbottom, north-east Cheshire (North-Western Naturalists' Union and local Societies); Rufford, between Ormskirk and Preston (also with North-Western Naturalists' Union); Chatsworth Park (Sorby Natural History Society) and Lickey Hill, Birmingham.

F. B. HORA
Foray Secretary

THE TWENTY-SEVENTH ANNUAL PLANT PATHOLOGY FIELD DAY

3 July 1953

The Twenty-seventh Annual Field Day was held at the Plant Pathology Department of Rothamsted Experimental Station. At 11 a.m. a party of about 70 members was welcomed by Mr F. C. Bawden on behalf of the Director.

Mr Bawden, Head of the Department, Mr H. L. Nixon and Dr Mary D. Glynne gave introductory talks on their fields of work. The rest of the morning was spent visiting the garden plots where Dr F. T. Last demonstrated his experiments on date of sowing spring barley and incidence of mildew; Mr Bawden (deputizing for Dr L. Broadbent) described the plots relating to crop preference of *Myzus persicae*, and Mr J. M. Hirst explained his methods of studying the epidemiology of potato blight.

After a sandwich lunch members were shown over the interesting Manor House by Mr Bawden.

The afternoon was spent visiting the laboratories and glasshouses. In the laboratories the following gave demonstrations—Mr J. M. Hirst, the automatic volumetric spore trap; Dr F. T. Last, the relation between growth and susceptibility to *Erysiphe graminis*; Mr H. L. Nixon, Miss J. Sampson and Mr H. L. Fisher, electron microscopy; Dr Mary D. Glynne, experiments on eyespot and take-all of wheat; Dr P. H. Gregory, a portable hand-operated trap for sampling the air spora; Dr A. Kleczkowski, effect of visible light following ultra-violet irradiation on bacteriophage, viruses and leaves; Mr I. Macfarlane, germination of resting spores of *Plasmodiophora brassicae*; and Mr O. J. Stedman, experiments on fungus spores in the wind tunnel.

In the glasshouses Dr Marion A. Watson and colleagues described experiments on screening sugar beet for resistance to yellows, and the effect of ultra-violet irradiation on the transmission of non-persistent viruses. Mr G. A. Salt and Mr D. Slope described their work on effect of date of sowing and date of application of nitrogen on take-all, and varietal reaction to eyespot of wheat.

At the end of the afternoon members were given tea, kindly provided by the Station, and the Chairman of the Plant Pathology Committee, Dr C. J. Hickman, thanked all those who had contributed to the success of the meeting.

C. C. V. Batts
Secretary, Plant Pathology Committee

THE BRITISH MYCOLOGICAL SOCIETY TRANSACTIONS

Vol.	PART 1	2	3	4	5
1	*m*	*m*	6*s.*	*m*	*m*
2	[		68*s.*		]
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4	*m*	*m*	—	—	—
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13	*m*	*m*	*m*	*m*
14	[	40*s.*		]
15	*m*	*m*	*m*	*m*
16	*m*	[	30*s.*	]
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REPRINTS AND MISCELLANEOUS PUBLICATIONS

Plant Pathology Committee: *List of Common British Plant Diseases*, 3rd Ed. 1945. Price net, 5*s.* Postage, 4*d.*

A. A. Pearson: *Cooke's illustrations of British Fungi* (*Annotations by L. Quélet, R. Maire & C. Rea*). *Ex* Vol. 20, Pt. 1. 1935. Price net, 2*s.* 6*d.* Postage, 3*d.*

T. Petch: *British Hypocreales. Ex* Vol. 21, Pts. 3 & 4. 1938. Price net, 2*s.* Postage, 3*d.*

A. A. Pearson & R. W. G. Dennis: *Revised list of British Agarics and Boleti. Ex* Vol. 31, Pts. 3 & 4. 1948. Price net, 5*s.* Postage, 3*d.*

J. Ramsbottom & F. L. Balfour-Browne: *List of Discomycetes recorded from the British Isles. Ex* Vol. 34, Pt. 1. 1951. Price net, 5*s.* Postage, 3*d.*

Fifty Year Index to The Transactions, Vols. 1–30; 1896–1946. Compiled by G. R. Bisby. Price net, 21*s.* Postage, 6*d.*

E. M. Blackwell: Haustoria of *Phytophthora infestans* and some other species. *Ex* Vol. 36, Pt. 2. 1953. Price 4*s.* Postage, 3*d.*

K. Sampson & J. H. Western: *Diseases of British Grasses and Herbage Legumes.* 2nd Edition. 1954. Price, 15*s.* Postage, 6*d.*

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(*To be obtained from the Treasurer and on sale at meetings and forays*)

A key to the genera of the agarics and Boleti. By A. A. Pearson. 32 pp. 1950. Price net, 2*s.* 6*d.* Postage, 2*d.*

Guide to the literature for the identification of British fungi. 1952. Price net, 2*s.* 6*d.* Postage, 2*d.*

Census Catalogue of British Lichens. By W. Watson. 1953. Price 7*s.* 6*d.*

CONTENTS

PAGE

Presidential Address: Fungi and water. By C. T. Ingold. (With portrait) . . 97

The ascogenous hyphae in *Daldinia*. By C. T. Ingold. (With 2 Text-figures) . . 108

Fungal parasites of the phytoplankton. III. By Hilda M. Canter (Mrs J. W. G. Lund). (With Plates 3–5 and 9 Text-figures) 111

Sommerstorffia spinosa and *Zoophagus insidians* predacious on rotifers, and *Rozellopsis inflata* the endoparasite of *Zoophagus*. By G. A. Prowse. (With 8 Text-figures) . . 134

The Nidulariaceae of the West Indies. By Harold J. Brodie and R. W. G. Dennis. (With 2 Text-figures) 151

Mastigosporium deschampsiae Jørstad in Great Britain. By P. K. C. Austwick. (With 2 Text-figures) 161

Two new combinations. By George Smith 166

Sclerotinia globosa in Britain. By John Webster. (With 1 Text-figure) . . . 168

Some predacious fungi occurring in dung. II. By A. J. Juniper. (With 3 Text-figures) 171

Reviews and Notices 176

Proceedings, 1953

Meetings 180

Annual General Meeting 181

Accounts: Receipts and Payments 182

The Spring Foray 183

The Dunkeld Foray, Scotland 185

London, Home Counties and Provincial Day Forays 191

The Twenty-seventh Annual Plant Pathology Field Day 192

INSTRUCTIONS TO AUTHORS

Contributors are asked to be clear and concise, and to use a recent issue of the *Transactions* as a guide to the arrangement of headings and subheadings, explanations of plates and figures, references to the literature, and other details. Each paper should start with a short summary. Contributors are urged not to adopt long serial titles and sub-titles.

The standards adopted in the *Transactions* are those outlined in the Royal Society's pamphlet, *General Notes on the Preparation of Scientific Papers* (1950, Cambridge University Press, 200 Euston Road, London, N.W. 1, price 2*s*. 6*d*.). An exception is that in the *Transactions* citations of references to literature, although based on the Harvard system, include the full titles of the papers and complete page numbers. Titles of journals are abbreviated in accordance with *A World List of Scientific Periodicals*, 1952.

The scientific names of genera and species are printed in italics and should be underlined in the typescript. The title of the paper, headings, and subheadings may be in capitals, but should not be underlined.

The attention of authors proposing new taxonomic groups is drawn to the need to give adequate descriptions and figures, and to designate the types as required by the *International Code of Botanical Nomenclature*. The description of a new species should be accompanied by a figure, and whenever possible the type specimen should be deposited in one of the national herbaria.

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